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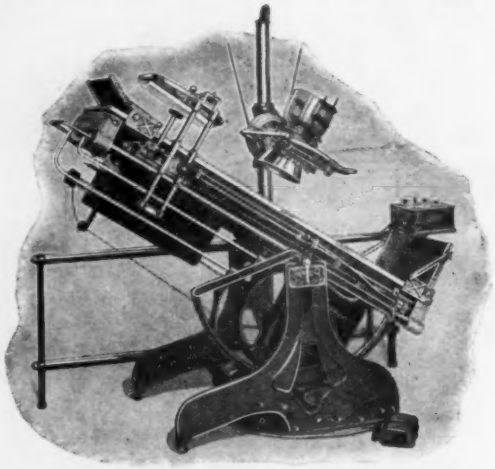

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor, H. M. Imboden, M.D., New York

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THE DIAGNOSIS OF PRIMARY TUMORS OF THE LUNG*

By ARTHUR C. CHRISTIE, M.D.

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WASHINGTON, D. C.

A CONSIDERATION of primary tumors of the lungs must deal largely with malignant tumors, since those of benign type are exceedingly rare.

The most comprehensive and accurate description of primary malignancies in the lungs is the monograph of Adler, published in 1912. Adler states that the first accurate knowledge of lung tumors dates from modern times, after Laennec had established the clinical investigation of the chest on a sound basis by application of ausculation and percussion. This he calls the period of the study of lung tumors by clinical methods supported by gross pathology. His latest period, coming down to the time of his monograph, is that in which histology is added to clinical and gross pathological research. Since the publication of Adler's treatise the perfection of the roentgen method of examination of the chest has brought us to another period of much greater accuracy in diagnosis of intrathoracic neoplasms. Indeed, Adler wrote as follows in 1912: "It was not very long ago that A. Frankel wrote that *x*-rays were of little service in the diagnosis of lung tumors. Since then the *x*-rays have become a most remarkable and efficient aid to diagnosis in general, and there exists the well-founded hope of their increasing efficiency as further improvements in apparatus and advances in technique are made. . . . . The hope may reasonably be entertained that with the systematic and proper application of the *x*-rays to the exploration of the chest, the diagnosis of lung tumor may be assured when no other means will give equally certain results."

In 1917 McMahon and Carman, in a communication on "The Roentgenological Diagnosis of Primary Carcinoma of the Lung," described in detail the roentgen appearance of these tumors and gave the essential points in differentiating them from other intrathoracic conditions.

It is the purpose of this paper to state as concisely as possible the diagnostic points by which we are now able to recognize the presence of primary tumors in the lungs and to emphasize certain conditions that have come under the writer's observation from which such tumors must be differentiated.

It is undoubtedly true, as several writers have stated, that there is a certain roentgen picture that is practically pathognomonic of primary carcinoma of the lungs, but there are certain other conditions so closely resembling it that constant watchfulness is necessary to avoid mistakes. It is essential in every case to interpret the roentgenogram

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14–17, 1920.

in the light of the symptoms, the physical findings, and especially the mode of onset and course of the disease. Unfortunately, like malignant disease in other parts of the body, tumors of the lung may be almost or quite symptomless, but in any case of suspected intrathoracic disease the possibility of lung tumor should always be considered.

The symptoms and physical signs depend not only upon the size of the tumor but more particularly upon its location.

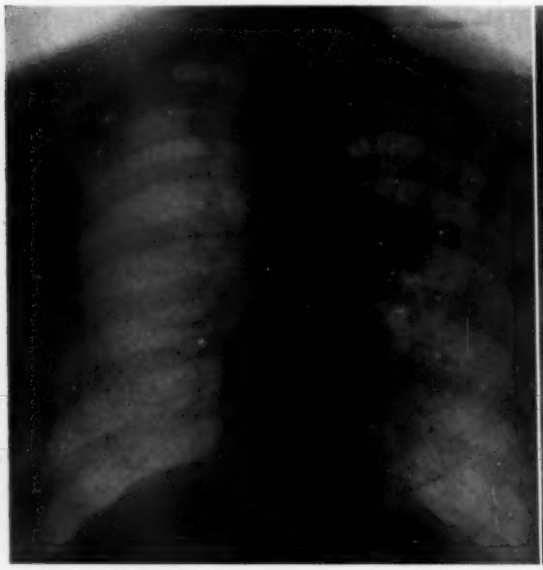

FIG. 1. PRIMARY CARCINOMA OF THE LUNG.

FIG. 2. BENIGN TUMOR—PROBABLY INTRATHORACIC GOITER.

There are usually no early symptoms that are characteristic, but there may be symptoms to arouse suspicion and lead to thorough investigation. Among the earliest of these may be a slight discomfort—at times amounting to pain—in an area corresponding to the hila of the lungs. There is often, also, a slight, gradually increasing dyspnea. Accompanying the discomfort and dyspnea there may be a dry, unproductive cough.

If these symptoms lead to careful physical examination of the chest, a small area of dullness may be discovered, especially a widening of the area of dullness about the root of the lung. There may also be diminished breath sounds, but no râles. If roentgen examination is made at this time, definite signs of pathology will be seen, depending upon the type of disease. If it is of the infiltrative type, having its origin in one of the large bronchi near the hilus, a roughly circular shadow will be seen extending outward from the hilus. The outer edge of this shadow is not sharply circumscribed but shades off into the surrounding lung shadow and has projecting from it processes that radiate out into the lung. Beyond this shadow which represents the pathological process itself is a more or less extensive area, somewhat less dense than the tumor shadow, and quite homogeneous in character. This is caused by congestion in the surrounding lung and probably also by a partial atelectasis due to some degree of stenosis of the bronchi. If in addition to the above picture there are a few nodules with the same indistinct edges surrounding the central shadow or in relation with the bronchial trunks farther toward the periphery, the picture is quite characteristic of malignant disease of the lung.

The infiltrative type of tumor may also arise from subdivisions of the bronchi or

from bronchioles far out in the lung structure. They show the same indistinct edges and projections as those arising at the hila.

In the miliary type of the disease there is diffuse nodulation throughout the lungs, but each nodule or mass of nodules has this same hazy appearance at its periphery, and there is present the surrounding zone due to congestion.

If the appearance described above is present, it may then be stated with a good degree of certainty that the lesion is carcinoma. There are, however, numerous cases of lung carcinoma in which the roentgen appearance is not entirely typical, and there are also conditions which are not carcinoma in which the roentgen appearance closely simulates the latter. It is in such cases that we must rely upon the future course of the disease and corroborative clinical findings in order to establish a diagnosis. The sputum may furnish conclusive or corroborative evidence. In rare cases tumor elements may be found or the fairly characteristic raspberry-jelly or prune-juice sputum may be present. The sputum is often bloody as in other lung diseases. The gradual increase in dyspnea due to growth of the tumor into the bronchi or trachea is a valuable sign. Barker mentions two cases in which he was led to a correct diagnosis by the presence of enlarged lymph-nodes in the neck. The microscopic examination of such a node removed from the neck or axilla may show the character of the process in the lung. The nature of the disease has occasionally been determined by the presence of portions of tumor in a pleural effusion. A hemorrhagic effusion is strongly suggestive of malignant disease.

It is stated that the diagnosis is sometimes established by bronchoscopic examination. Fever is of variable occurrence and is probably due to the presence of inflammatory reaction about the tumor. It may vary from 99° to 102.5°.

Two cases of lung carcinoma which have come under the writer's observation depend for diagnosis upon the manner of onset, the progressive course of the disease, and the roentgen findings, which are quite typical. Both of these cases were men between fifty-five and sixty years of age. The clinical and roentgen aspects of these two cases are strikingly alike. In both cases the first sign of the disease was a sudden attack of fever and cough. The fever disappeared in a few days, but the dry cough persisted. In one of the cases there were several attacks of fever varying from 99° to 102.5°. One came for roentgen examination eight months, and the

FIG. 3. BENIGN TUMOR, PROBABLY DERMOID CYST.

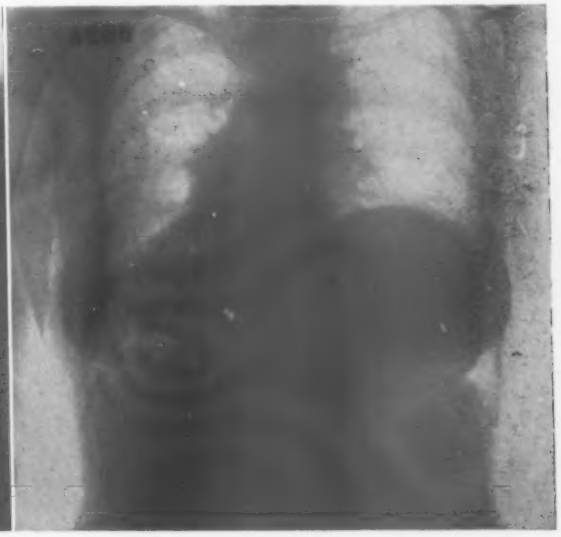

FIG. 4. ECHINOCOCCUS CYST OF LUNG.

other six months after the initial attack of fever. In one of them the clinician had discovered a definite area of dullness extending outward from the left hilus—in the other no suspicious physical signs had been found in the chest. In both cases the most prominent symptom was the persistent, irritating cough, but both complained of a feeling of tightness and discomfort in the region of the root of the left lung. Both patients had a slightly cachetic appearance and both had lost a few pounds in weight. Both cases have been given two series of roentgen treatment through many portals of entry with no apparent improvement. One has been under observation about four months, and the other about six months, and in both there has been a gradual increase in the cachetic appearance and a gradual loss of weight. Figure 1 shows the roentgen appearance in one of these two cases.

Benign tumors of the lung occur infrequently but often enough to make it necessary to mention them briefly. It is often possible to make a diagnosis of benign lung tumor when the exact nature of the tumor cannot be stated. For example, Figures 2 and 3 undoubtedly represent benign tumors since they were both observed over a period of more than three years without change in size or contour. Figure 2 is probably an intrathoracic goiter, while Figure 3 is very likely a dermoid cyst.

Echinococcus cyst sometimes occurs in the lung, usually in the lower right lobe. Figure 4 represents a cyst which is believed to be echinococcus, but conclusive evidence such as hooklets in the sputum or positive complement fixation test, was absent. The round or oval, sharply circumscribed contour of benign tumors and their smooth margin makes their roentgen appearance rather typical.

Fig. 5. Mediastinal Tumor.

Fig. 6. Mediastinal Tumor.

The following intrathoracic conditions may simulate lung tumors more or less closely and must be considered in the differential diagnosis.

Mediastinal tumor can usually be distinguished by the roentgenologic appearance. Oblique examination will show a distinct mass in the mediastinum, and examination in the antero-posterior direction will show the shadow directly continuous with

that of the mediastinal structures. (Figs. 5 and 6.)

In mediastinitis there is a general widening of the mediastinal shadow, and those

Fig. 7. Intrathoracic Goiter.

signs and symptoms that accompany an inflammatory process.

Intrathoracic goiter and *cystic tumors* of the mediastinum give a rather characteristic roentgen picture. (Fig. 7.)

Gumma of the lung is a condition having much the same roentgen appearance as malignant tumors (Figs. 8 and 9). The diagnosis depends upon the Wassermann test and the disappearance of the mass under anti-syphilitic treatment.

Caseous pneumonia may readily be mistaken for malignancy. The early symptoms may be quite indefinite just as they are in malignant disease, and the roentgen picture may not be distinctive. The irregular temperature, gradually becoming higher as the disease progresses, the presence of râles, the finding of tubercle bacilli in the sputum, and the character of the sputum may serve to differentiate from lung tumors.

There are certain inflammatory processes occurring at or near the hila of the lungs that give much the same roentgen appearance as malignant disease. Such conditions are often seen following influenza, but they may arise quite independently of other disease. We have observed several such cases apparently caused by the streptococcus hemolyticus. These conditions are sometimes a bronchial adenopathy but some of them are undoubtedly localized pneumonic processes. Most of them undergo resolution very slowly and it is at this time, when the patient is afebrile, that a mistake may be made in

Fig. 8. Gumma of Lung.

Fig. 9. Gumma of Lung. Same Case as Fig. 8 after Treatment.

diagnosing the condition as malignancy of the lung.

There are other conditions, such as bronchiectasis, chronic pulmonary abscess, encysted empyema, pulmonary infarct, and metastatic malignancy, that may be confused with primary malignant tumor of the lung. Careful attention to the history and the roentgenologic findings will in most cases serve to separate them.

It may be stated in conclusion that an accurate diagnosis of lung tumor, with a definite opinion as to its malignant or benign character, can be made in many cases by consideration of the mode of onset, the preliminary symptoms, and the roentgen findings. When, however, the roentgen appearance is not characteristic, the diagnosis must be established by the further course of the disease, and the presence of such signs as enlarged lymph nodes in the neck or axilla, and the character of the sputum and pleural effusions.

It must further be kept in mind that there are certain non-cancerous conditions occurring in the lung which may readily be confused with cancer, especially if only the roentgenologic evidence is relied upon. Among those especially likely to lead to error are gumma of the lung, mediastinitis, caseous pneumonia, and certain inflammatory processes about the hila.

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DISCUSSION

Dr. G. E. PFAHLER.—This paper has been so beautifully presented I don't see that there is very much to add. I can only congratulate Dr. Christie on his presentation.

DR. F. W. MANGES.—I too think Dr. Christie's a most interesting and important paper. It has been but a comparatively short time that we have been considering primary carcinoma of the lung, except as a very rare entity, if an entity at all, and I think largely because of the roentgen signs which we found difficult to explain otherwise. In other words, it has been because we have not been able to differentiate our findings clearly that the diagnosis of primary carcinoma has become quite common in the last few years, so that I think this is a most important question now, especially to roentgenologists. Every year our problems of differentiating conditions in the chest are becoming more and more difficult, more and more complex. It must prove to all of us that we made many mistakes in the past, so that I think the paper of Dr. Christie, like that of Dr. Watkins and a number of others on the chest at this meeting, have been most valuable indeed.

I am not going to discuss the paper in the sense that I disagree in any way with Dr. Christie, because I don't. I would like to support practically everything he said.

DR. GEORGE C. JOHNSTON.—I have never seen a case of pleural effusion in primary malignancy. It may be that the cases are not

far enough advanced or that they die too soon, or I don't get to see any of them. It is my opinion you get your pleural effusion in secondary carcinoma.

Now, if we take up these cases of primary carcinoma, pretty soon we will have the internist thinking about it when he is examining a man, and you will find they are not at all rare, but are simply overlooked. I have seen a number of cases of primary carcinoma of the lung, and to my surprise, I found they were practically all coming from one man, and he was not the best posted internist I had to work for, either. He was one of the old school of men, and in curiosity I asked him why he was making so many diagnoses of carcinoma of the lung that we could support roentgenologically. He said it was probably because he was thinking about it when he examined the patient. Then I asked him what he based his diagnosis on in some of these cases, and he replied that if you are going to explain afebrile hemoptysis without any pneumonia, it is pretty hard to do.

Dr. A. C. Christie (closing). We often have pleural effusions in primary carcinoma. One of these cases of mine had a pleural effusion, and many reported have had pleural effusions which had to be withdrawn before an accurate picture could be obtained.

I would like to emphasize what Dr. Manges said that the disease is common. It is not such an uncommon disease as we once believed and we must think about it always. Adler reported 374 cases in 1912, and he accepted only those which had been proven by pathologic section. McMahon and Carman reported some 460 cases in 1918. There may have been quite a number since, so there must be a great many more cases than have been reported. Some think it is not very important whether we make an actual diagnosis or not, because the patient is doomed any way, but I think it is a matter of great importance to the patient. Aside from the question of scientific accuracy in diagnosis, it is of great moment to the patient whether he is going to be moved around from here to there as a tuberculosis patient for the rest of his life, with the final destruction of false hopes that he may get well, or whether it is definitely known from the beginning that he has a malignant disease.

THE CLINICAL IMPORTANCE OF THE DIFFERENT TYPES OF PULMONARY TUBERCULOSIS AS DETERMINED BY ROENTGEN EXAMINATION*

By R. G. ALLISON, M.D.

MINNEAPOLIS, MINNESOTA

IN attempting to classify pulmonary tuberculosis into clinical and non-clinical types by means of the *x*-ray, I would like to assure you at the outset that I am fully aware of the difficulties that are to be met with, and am convinced that it cannot be done without a certain percentage of error. I am equally convinced that unless we do attempt this classification we have not done our full duty either by the patient or by the clinician who has referred him to us for an opinion. Entirely too much time has been spent by both roentgenologists and clinicians in advancing absurd claims as to the relative merits of the stethoscope and the *x*-ray in discovering the earliest tuberculous change in the lungs, and entirely too little time spent by either of them in investigating the clinical significance of the lesions when found.

In the past there has been too much hesitancy on the part of the roentgenologist to make, and on the part of the clinician to accept negative diagnoses of pulmonary tuberculosis in the face of toxic symptoms.

Giffin of the Mayo Clinic says: "From the comparison of the two methods we would conclude that pulmonary tuberculosis can be shown as early by the *x*-ray as we can be sure of its presence by other methods, and the negative evidence obtained has in our

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

experience been of greater value than the positive." Lawrason Brown of Saranac Lake says: "By stereoscopic plates a diagnosis can be made long before physical signs are definite." Rist of the Lannec Hospital of Paris states: "To argue that a pulmonary tuberculosis sufficient to give physical signs would not show definitely on the *x*-ray plate, shows an ignorance not only of the fundamental principles of roentgenology, but of physical diagnosis as well." Thus it would seem that in stereoscopic plates we have the one accurate method of definitely excluding pulmonary tuberculosis.

It is my belief that the greatest factor in making roentgenologists reluctant to make, and clinicians reluctant to accept negative diagnoses of pulmonary tuberculosis, has been the non-recognition or non-acceptance of the fact that there are no symptoms or set of symptoms pathognomic of pulmonary tuberculosis. Until clinicians and roentgenologists accept this fact, the one will be always loathe to make and the other loathe to accept a negative diagnosis in the face of toxic symptoms. Further in this relation I would include in the category of negative diagnosis of pulmonary tuberculosis not only normal lungs, but also lungs showing non-clinical types of tuberculosis.

In my opinion our reports to the referring physician should consist of an objective description of our findings, our impression of these in terms of pathology, and finally our opinion as to whether the lesion is or is not a clinical type of infection. If all our cases were referred by internists and tuberculosis specialists capable of translating objective descriptions of shadows into terms of pathology either obsolete or recent, this might not be necessary; but the majority of cases do not come from them. It has been my experience that by far the greater number of chest cases referred to the roentgenologists come from the general practitioner; and the majority of these are sent for the simple reason that they are presenting symptoms suggestive of an active tuberculosis, with absent or equivocal signs, and the information which the physician desires can be summed up in two questions: (1) Has this patient pulmonary tuberculosis? (2) If so, is it of a type which could account for his symptoms? It is my belief that the first question can be answered correctly in practically every instance. The second can be answered with such a high degree of accuracy, that it should never be neglected, especially as it is the question upon which the whole value of the roentgen method depends. So much has been written on the early diagnosis of pulmonary tuberculosis, and the fact that physical signs may be absent so emphasized, that as Rist aptly expresses it, confronted by a patient, our attitude is not "What ails the patient?" but "Can't we find some tuberculosis to account for his symptoms?" It is in this type of case—and these form at least half of the cases we see—where by making a definite negative diagnosis of a clinical type of tuberculosis, we can start the physician on a further search for the real cause of the patient's symptoms.

Otherwise, if we describe an obsolete tuberculosis as seen on the plates, without an expression as to its clinical significance, the physician will immediately attribute the symptoms to it and the patient be doomed to a sanitarium existence, with all the interference with his future life which that entails. Only a week ago I heard one of our noted sanitarium physicians say: "It is only since I have become convinced of the value of a negative *x*-ray diagnosis of tuberculosis that I found how many different conditions I had been treating as pulmonary tuberculosis."

We as roentgenologists would be far more accurate and valuable if we would confine ourselves to speaking in terms of clinical and non-clinical types of tuberculosis and base our opinions wholly upon the findings of the plates, rather than be biased by the patient's symptoms, and attribute activity to an obsolete infection. Naturally the patient has symptoms or he would not have consulted his physician, and his symptoms are suggestive of pulmonary tuberculosis or he would not have been sent to us. Our duty is to say

whether there is a pulmonary tuberculosis present which is capable of producing symptoms, and there our duty ends.

I hope I may be pardoned for having dwelt so long on these simple facts, but for five years I worked in clinical tuberculosis, and during part of that time I received dictated chest reports. During that time the reports were a conglomeration of "increased linear markings," "bronchial interweavings," "tobacco smoke cloudings," and "apical shadows," without any attempt generally to convert these findings into terms of pathology and anatomy and never any attempt to state their clinical significance. Usually I was more in doubt as to what the patient had after reading the reports than before. It is because I can see this from the standpoint of the clinician that I have dwelt so long on the necessity and value of an opinion from the roentgenologists as to the etiology and clinical significance of the objective findings.

From a roentgen standpoint all pulmonary tuberculosis can be grouped under three divisions: (1) The pulmonary miliary process which accompanies a generalized miliary tuberculosis and is hematogenous in origin. Its appearance is characteristic, readily recognized, and seldom confused with other conditions. Its clinical significance need not be touched upon. All pulmonary tuberculosis other than this form can be classified definitely as either (2) parenchymatous or (3) peribronchial, depending upon whether the involvement is in the lymphoid tissue surrounding the bronchus or in the air vesicles themselves. In case both types are present it should be classified as parenchymatous.

The roentgen differentiation of these two types is simple, definite and necessary. It is beyond the scope of this article to delve into the different theories on the mode of infection in pulmonary tuberculosis.

Gohn's classical work on the lungs of children would indicate that all peribronchial tuberculosis is secondary to a parenchymal focus, which may be active or healed, large or small. Regardless of its etiology peribronchial tuberculosis can be definitely differentiated from the parenchymal form by the *x*-ray. The roentgen appearance of parenchymatous tuberculosis from its slightest to its most advanced changes is perfectly familiar to all of us and a description need not be indulged in. The only condition which resembles it closely is an atypical bronchial pneumonia, and here at times we must resort to the time-honored custom of watchful waiting in order to decide with which condition we are dealing. With a history of recent influenza or pneumonia I should wait for a few weeks, for a second set of plates, before pronouncing a slight infiltration or consolidation tuberculous unless there were definite evidence of fibrosis or calcification present.

If the conglomerate tubercles which make up this type of infection are few in number and definitely calcified, and the linear markings extending toward the hilus from them show a cleancut shadow, I do not consider the lesion of clinical significance. Unless it does exhibit this appearance I report it as a clinical type of infection.

Peribronchial tuberculosis, to be considered of clinical importance, should be upper or middle lobe distribution, gross in amount, either unilateral or more marked on one side as compared with the other, and should exhibit a hazy outline and a definite nodular appearance. Unless involvement of the peribronchial tissue conforms to these qualifications it represents either a non-tuberculous infection or is merely the residue of an obsolete tuberculosis.

I have followed the plan just outlined in reporting all chest cases. I have first given the objective findings, then attempted to convert these into terms of pathology. Following this I have then given a positive or negative opinion as to the clinical significance of the lesion.

I have probably missed several cases of active tuberculosis, and I am quite sure that in many of the cases I described as having a clinical type of tuberculosis, the tuberculosis was quiescent and the cases were suffering from other conditions which were producing their symptoms. But on the other hand I am

quite sure that in most instances where a negative diagnosis was given, the physician by a further search was able to find some other disease as the cause of the patient's symptoms.

CONCLUSIONS

1. Pulmonary tuberculosis can be divided into clinical and non-clinical types with a high degree of accuracy by stereoscopic plates.

2. Unless we make this division into the two types we are putting our method on the level of tuberculin, which will not differentiate between infection with the tubercle bacillus and the disease tuberculosis.

3. Negative stereoscopic plates can with an occasional rare exception exclude a clinical type of tuberculosis.

4. Parenchymatous tuberculosis is a clinical type unless slight in amount and definitely calcified, and peribronchial tuberculosis is of clinical significance only where it conforms to the following qualifications, upper or middle lobe distribution, unilateral or more marked on one side as compared with the opposite, gross in amount and presenting a hazy outline with definite modulations.

5. A negative diagnosis from the roentgenologist is of more value than a positive, in that in the face of suggestive symptoms, a positive diagnosis can often be made by other methods, but the *x*-ray alone offers the only accurate method of excluding the disease.

THE VALUE OF LATERAL AND OBLIQUE STUDIES OF THE CHEST*

By WILLIAM A. EVANS, M.D.

DETROIT, MICHIGAN

IN reviewing the literature on tuberculosis in children, one wonders at the wide variance of opinion held by men prominent in chest work as to diagnosis and location of lesions. It is agreed that the diagnosis is difficult, and while one writer insists that physical signs are to be depended on first, if not almost entirely, another declares that the ordinary methods of examination are of little value, and that history alone will suffice to determine the diagnosis.

References to the pulmonary area involved are equally conflicting. Fishberg, in an article in the Medical Record in 1917, states that parenchymal lesions are invariably apical, as in adults. This is in direct contradiction to the usual view that parenchymal tuberculosis in children is invariably of the lower lobes. Most of the later workers agree that the roentgen method of examination of the chest is most valuable, some declaring that it is the only method by which a correct diagnosis can be made. Inasmuch as parenchymal tuberculosis is extremely rare in childhood, and peribronchial tuberculosis and a peribronchial lymph node tuberculosis are but secondary developments of a primary root infection, it is evident that the ordinary postero-anterior plates of the chest cannot have a proper diagnostic value for tuberculosis, since the visible changes in this condition to a large extent and for some time occur in the nodes which surround the trachea and the first portion of the bronchi, and these structures are obscured by the heart and large vessel shadows.

We have had the opportunity recently to check physical and radiographic findings, and it has been observed in the cases in which the infection had spread to the outer bronchial, bronchopulmonary and pulmonary nodes, the findings were in harmony, but when the physical findings—and in these cases the d'Espine sign was held diagnostic—were not in accord with the pathology demonstrated by the ordinary plates, lateral

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

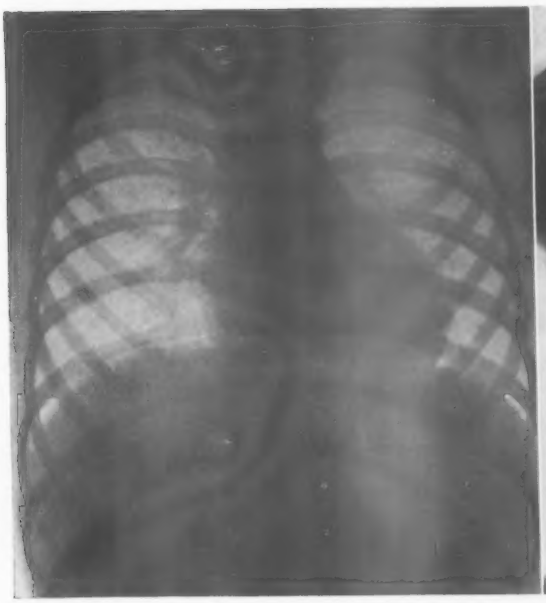

FIG. 1. CASE I. AN ORDINARY POSTERIOR-ANTERIOR PLATE OF A CHILD'S CHEST SHOWING THE ACCENTUATION OF THE HILUM SHADOWS AND INCREASED MARKINGS UPWARDS.

FIG. 3. CASE II. ORDINARY POSTERO-ANTERIOR PLATE OF THE CHEST OF A CHILD. NO ABNORMALITY NOTED.

FIG. 2. CASE I. LATERAL PLATE OF THE CHEST SHOWING THE CALCIFIED GLANDS AND MARKED HYPERTROPHY OF THE LYMPHOID TISSUES IN THE SPACE BETWEEN THE HEART AND THE SPINE.

FIG. 4. CASE II. LATERAL PLATE OF THE CHEST SHOWING EXTENSIVE DEPOSIT BETWEEN THE HEART AND SPINE.

plates revealed the enlargement of the tracheal and inner bronchial glands.

We are not to gather from these statements that the diagnosis of tracheobronchial tuberculosis can be made from the radiographic examination alone, for there is nothing characteristic about the enlargement of the glands resulting from infection with the Koch bacillus; but it is important to use a method which will demonstrate the basis for physical signs, and the lateral plate will do this frequently when the standard positions give negative findings.

At this time, I should like to refer to the results of experiments by Krause given in a paper entitled "Experimental Tracheobronchial Node Tuberculosis" published in the *American Review of Tuberculosis*, March, 1919. In these experiments an attenuated strain of Koch bacillus was injected in the groins of guinea pigs. Serial studies demonstrated an early and relatively extensive involvement of all of the lymph nodes in the vicinity of the point of infection. It was supposed for some time that the infection did not spread beyond the abdominal lymph nodes, but later studies showed in all cases involvement of the tracheo-bronchial nodes. Dr. Krause's conclusions from these experiments tend to disprove definitely the Ghon theory that all tuberculosis of the hilus glands is secondary to a pulmonary parenchymal lesion. Dr. Krause suggests that he could agree with Ghon's theory provided the word infection was used rather than lesion, because it is no doubt true that the lymph nodes are, in many cases, infected by inhalation, the organisms being absorbed by the terminal pulmonary lymph vessels.

The value of the lateral study of the chest in adults is particularly great in those cases which present deep-seated abscesses or interlobar collections of fluid. The position of parietal effusions can be easily determined by plates made in both anteroposterior and postero-anterior positions, the size of the shadow, of course, varying on the two sets of plates. The ordinary stereoscopic plates are of no value in these diffuse intrathoracic shadows, because the relation of the density to the anterior or posterior chest walls cannot be determined by this method of study. If the margins of the encapsulated fluid were always spherical or regular, the lateral method would have no special advantage; but frequently the outline of a retained fluid is triangular, so that by the lateral plates the points of approach for thoracentesis or thoracotomy can be advantageously chosen.

The possibility of a successful drainage of a lung abscess by collapse of the lung through artificial pneumothorax can also be determined in advance of the procedure, for in abscesses which are situated near the periphery of the lung, there are frequently adhesions between the pulmonary and parietal pleurae, which prevent lung collapse. This question is especially timely because there are many internists in the country who are electing to treat acute pulmonary conditions by artificial pneumothorax when the pathology present should demand surgical treatment.

The shadow of the right leaf of the diaphragm on the average chest plate is at the level of the eighth or ninth rib posteriorly, the exact level depending on whether the plates were obtained in deep inspiration or in expiration. The lines of reflection of the pleura inferiorly are anteriorly at the level of the eighth costochondral junction, mammary line, the tenth rib in the midaxillary line, and thence to the spinous process of the twelfth thoracic vertebra. The variation between the two sides is unimportant. Therefore any pathology occurring in the posterior phrenocostal space cannot be shown on the standard anteroposterior plates. It is true that plates made in deep inspiration reduce the depth of this hidden field, but at no time is the diaphragm entirely flat. Again, any inflammatory pathology involving the lower lobes causes a fixation and elevation of the diaphragm on the affected side, and the depth of the area under discussion is correspondingly increased.

The lower right lobe is a favorite locality for abscess, probably due to the predilection for foreign bodies to enter the right bronchus.

FIG. 5. CASE III. ORDINARY POSTERO-ANTERIOR PLATE OF AN ADULT'S CHEST SHOWING A HYDROPNEUMOTHORAX.

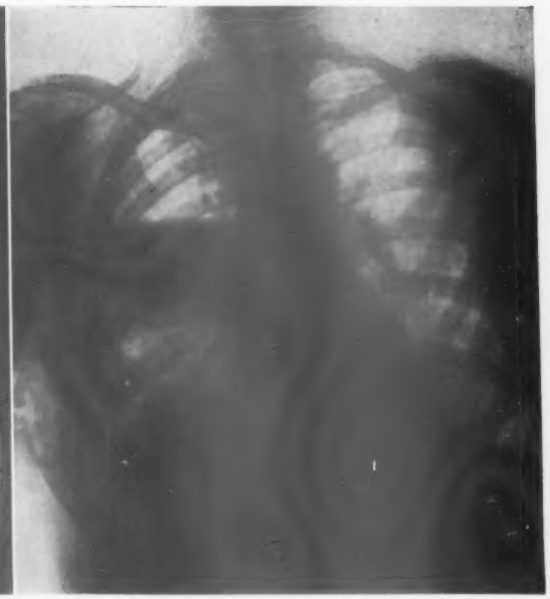

FIG. 7. CASE IV. POSTERO-ANTERIOR PLATE OF THE CHEST SHOWING A HYDROTHORAX.

FIG. 6. CASE III. LATERAL PLATE SHOWING THE COLLECTION OF FLUID IN THE POSTERIOR PART OF THE CHEST. NOTE FLUID LEVEL OVERLYING THE SHADOW OF THE SPINE.

FIG. 8. CASE IV. LATERAL PLATE OF THE CHEST SHOWING THE WIDE DISTRIBUTION OF FLUID FROM THE ANTERIOR TO POSTERIOR CHEST WALL.

Descriptions of three cases recently studied will serve to illustrate the practical value of the lateral and oblique studies of this area.

Case I. Mrs. S, age forty-five. Referred for chest examination with the history of an acute process in the lower right. The findings, at this time, were those of a small amount of fluid in the right lower pleural cavity, there being a loss of the phrenocostal angle. However, the development and severity of the symptoms were out of proportion to the findings, and following withdrawal of the pleural effusion, further studies were undertaken to determine the basis for the persistence of the symptoms. At this time, by the oblique method, we could demonstrate a rounded shadow just below the shadow of the right leaf of the diaphragm, and accordingly a report was made that a lung abscess was present, and that the pleural effusion formerly demonstrated was simply secondary to the deeper lesion. Several days following this examination, in a paroxysm of coughing, the patient brought up a peanut with a quantity of pus, and the case went on from this to complete recovery. At the time of both examinations, no history whatever was obtained that would suggest the presence of a foreign body.

Case II. Mr. C., age twenty-three. The chest plates showed pulmonary pathology involving the lower right lobe, complicated with a small amount of pleural effusion. The patient apparently recovered from this condition, although previous to his discharge from the hospital no radiographic record was obtained of the chest condition. After a lapse of three months, the patient was again referred for examination of the abdomen, with a tentative diagnosis of duodenal perforation or duodenal ulcer. Study of the chest at this time revealed a fixed and elevated right leaf of the diaphragm, with no free fluid in the pleural cavity. The abdominal findings were those of adhesions involving the first and second portions of the duodenum. We described the pathology in the lower lobe, but we did not appreciate its clinical significance, as later events proved.

At operation, adhesions were found in the upper right quadrant, but during the anesthesia, the patient had a severe paroxysm of coughing, and a considerable quantity of pus was expectorated.

We felt that we were at fault in this case, because we did not attach more importance to the pulmonary findings. Due consideration of the oblique findings would have resulted in a very different method of treatment.

Case III. Mr. C., age seventy, with a history of pneumonia which did not clear up within the usual period. Radiographic study of the chest in the standard positions demonstrated a small amount of fluid in the lower right. Again, the symptoms were out of proportion to the findings, and the oblique method of study revealed lower lobe pathology, in addition to the small amount of fluid.

At the time of operation, when the pleural cavity was opened, there was escape of a thin, sanguineous fluid, and not until the lung itself was entered was pus obtained.

A third area in the chest obscured by anatomic structures is the space between the heart and the posterior chest wall. Internists have frequently questioned the interpretation of chest findings in a given case, inquiring as to the possibility of a pulmonary lesion being obscured by the heart shadow. Our experience with Case IV of this series will serve to emphasize the need of having in mind the possibility of collections of fluid which can be obscured by the heart, the heart in the meantime showing no displacement.

Case IV. Mr. H., age twenty-six, postinfluenzal pathology. The anteroposterior plate showed slight impairment of density over the lower left lung field, with a visible left leaf of the diaphragm and no displacement of the mediastinal shadows. In spite of

our negative report for the presence of any quantity of fluid in the left pleural cavity, a thoracotomy was performed and a pint or more of pus was evacuated. In this case, also, we believe that thorough lateral and oblique studies would have revealed this collection of fluid.

FIG. 9. CASE V. POSTERO-ANTERIOR PLATE OF AN ADULT'S CHEST SHOWING ELEVATION AND DISTORTION OF THE RIGHT LEAF OF THE DIAPHRAGM.

CONCLUSIONS

I am well aware that the above procedure in the examination of the chest is carried on by many workers. My object in presenting it at this time is to emphasize the necessity for a more frequent variation from the standard positions.

The mere reporting of a small amount of fluid in the lower pleural cavity is of no practical value in many chest conditions, for the presence of the fluid is merely incidental to the basic pathology, which is pulmonary.

As regards juvenile tuberculosis, the wide divergence of opinion regarding the mode of infection and the distribution of lesions indicates the necessity for immediate and wide promulgation of the views held by roentgenologists who are familiar with the type and location of visible lesions of tuberculosis.

DISCUSSION

DR. KENNON DUNHAM. I wish to thank Dr. Evans for bringing to our attention again the necessity for as complete an examination of the chest by the *x*-ray as is possible. I am sure that he does not mean that we should give up the ordinary stereoscopic postero-anterior ex-

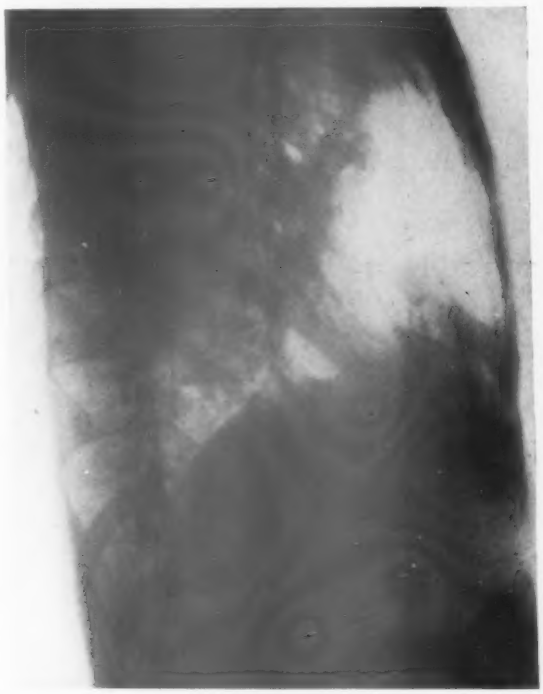

FIG. 10. CASE V. LATERAL PLATE OF THE CHEST SHOWS ADHESIONS INVOLVING THE DIAPHRAGM WELL INTERIOR. THE POSTERIOR SURFACE IS CLEAR.

This plate shows graphically the extent of the pulmonary area which is obscured by the ordinary postero-anterior plate.

posures from which we gain so much, but he does mean, or at least I think he means, that that is not always sufficient, and it is of utmost importance that every aid should be given to determining these lung tumors. For years *x*-ray men have been working in the lung field, and have had almost no encouragement from the medical profession. The war changed that. They are coming to you and to me to help them solve their chest problems. Just as in Dr. Stewart's work, the bronchoscopist is absolutely dependent on the *x*-ray examination. Now, when we have made an examination, don't let us stop because we are in a hurry. Don't let us get

into a hurry which may cause us to lose an important phase of an examination.

Before I sit down, I simply wish to impress on you that wherever it is possible, please impress upon your clinician that the aid of the *x*-ray is not only necessary in cases they think are important; the great importance of the *x*-ray examination of the chest is where they do not have sufficient physical signs to explain the case. The greatest benefit we have received from the *x*-ray examination has been where it has been done routinely. Every case coming to a hospital should be examined, and that is where you get your beautiful results and most illuminating work. It helps the clinician and then, for the first time in the clinician's life, he wakens up to the fact that his physical examination has its limitations just as the *x*-ray examination has its limitations.

But this method of Dr. Evans' impresses on us the value of the lateral and oblique exposures of the root of the lung, and possesses inestimable value. The stereoscopic plate becomes helpless in front of an absolute density. We cannot stereoscope heavy densities—we do not stereoscope the heart, but they must be studied, and to do this we must find a way. Dr. Evans has shown the way.

A SIMPLE AND PRACTICAL METHOD FOR THE RAPID HARDENING OF GAS TUBES

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NEW YORK CITY

AT the present time there are three recognized methods of hardening gas tubes which have become too soft for use:

1. Tubes may be hardened by setting them aside and allowing them to rest for an indefinite period.

2. Tubes may be hardened by passing a weak current through them for several minutes, either through the true or through the accessory anode. The current must pass through the tube until the tube is hot.

3. Tubes may be hardened by being repumped at the factory. The first two methods are time-consuming and unreliable, failing completely in the case of very soft tubes. The third method is time-consuming, inconvenient and expensive.

The possibility of hardening *x*-ray tubes rapidly and conveniently by cooling the softening device with an ethyl-chloride spray or other means suggested itself on theoretical grounds. The efficacy of the method has been demonstrated by the successful hardening of twenty-five different gas tubes. Up to the time of publication fifty tubes have been successfully hardened. After a short discussion of theoretical considerations we shall give in detail our practical methods and results.

THEORETICAL CONSIDERATIONS

The fact that gas tubes become harder on standing suggests the occurrence of condensation and absorption or adsorption of gas by the tube wall, anode or softening device, and particularly the condensation and absorption of water vapor. The experimental work which resulted in the production of high-vacuum Coolidge tubes taught us that the ordinary low-vacuum tube contains a considerable amount of water vapor. The construction of the ordinary softening device, which consists of some hygroscopic material, such as asbestos packing so placed that it can be heated by the electric current, leads us to believe that the softening of the tube consists generally in the liberation of water vapor and that the hardening which takes place on standing is mainly due to the resorption of the water vapor previously lib-

erated. While the condition of the tube wall and that of the anode and cathode are undoubtedly factors in the state of hardness of the tube, it is probable that most of the resorption takes place in the softening device which, because of its relatively large surface and hygroscopic character, is best adapted for this function.

The avidity with which finely divided substances, such as animal charcoal, absorb gases when cooled to a very low temperature, as by liquid air, suggests the possibility of hastening the resorption of gas or water vapor in a gas tube by cooling the softening device. The rapid fall in vapor tension of water with fall of temperature suggests that the use of even a mild cooling device, such as the ethyl-chloride spray, will be fairly efficacious in causing condensation or increased concentration of water vapor in the cool part of the tube and hence increased resorption and consequently increased exhaustion or hardness. These theoretical considerations are borne out by the practical results which follow.

PRACTICAL METHOD AND RESULTS

The actual method of hardening the tube is as follows:

1. Current is passed through the tube until it becomes fairly hot.

2. The softening device of the *x*-ray tube is sprayed slowly with ethyl-chloride. From thirty to fifty grams is generally sufficient, and during the spraying a coating of snow and ice should collect on the glass bulb of the softening device. It is advisable to protect the bulb of the tube with a towel, exposing only the chamber containing the softening device. A thin layer of absorbent cotton held down by two or three rubber bands placed around the tube wall containing the softening device facilitates the spraying of ethyl chloride. By this method none of the ethyl chloride is wasted or lost and the formation of snow and ice is hastened.

3. Allow the tube to stand five minutes. Dry the tube thoroughly. An electric fan aids in cooling the softening device during the spraying, and also later in drying the chamber containing the softening device.

4. Reheat the tube by passing the current through the anticathode or accessory anode. After this procedure it is generally found that the tube is harder than before and becomes progressively harder for about twenty-four to forty-eight hours. Different tubes vary in the ease with which they are hardened; some require only one treatment and others several repetitions of the treatment. Once the spark-gap has begun to increase it is easy to increase the hardness of the tube to any desired degree by repetition of the above treatment.

On the following page will be found a table containing a list of twenty-five tubes rehardened by this method.

SUMMARY

As a result of our experiments with twenty-five gas tubes of several different types, we wish to emphasize several points which will be useful to any one employing this procedure. It makes very little difference whether the asbestos packing in the softening device is in direct contact with the outer glass wall or is contained in a separate tube. In general older and more highly seasoned tubes require more preliminary heating and respond to treatment more slowly than do newer tubes. The reason for this is that the tube must be heated sufficiently to drive particles of gas from the metal parts and glass wall into the bulb so as to allow this gas to be absorbed by the softening material. Several treatments may be necessary, but once the spark gap has begun to increase it is a simple matter to attain any degree of desired hardness. Frequently it will be found that tubes will show almost no change immediately after treatment but become much harder from one to twenty-four hours after. If at the end of twelve to twenty-four hours the tube does not tend to become harder, another treatment is indicated. Tubes hardened by this method will keep their vacuum and gap indefinitely, as shown by their daily use in the *x*-ray labora-

tory of Mount Sinai Hospital, New York City. The tendency of these tubes upon standing is to become progressively harder.

We have not had experience with tubes containing metallic regulators as softening devices, therefore cannot state whether this method is applicable to such tubes. Our experience has been limited to tubes containing hygroscopic material.

CONCLUSION

In conclusion, we feel that both theoretical considerations and practical results justify us in stating that *gas tubes containing some hygroscopic material such as asbestos packing can be hardened rapidly and conveniently by cooling the softening device by an ethyl-chloride spray.*

TABLE I

TUBE	SPARK GAP BEFORE HARDENING	SPARK GAP ONE HOUR AFTER HARDENING	SPARK GAP 24 HOURS AFTER HARDENING	SPARK GAP 48 HOURS AFTER HARDENING	REMARKS
1	Less than 2 in.	3 inches	5 inches	7 inches	Soft since 1916
2	Less than 2 in.	No change	4 inches	7½ inches	Soft since 1916
3	Less than 2 in.	No change	6 inches	6 inches	Soft since 1916
4	Less than 2 in.	3 inches	6 inches	6½ inches	
5	2 inches	5 inches	7 inches	7 inches	Helium
6	Less than 2 in.	4 inches	7 inches	8 inches	Accidentally Softened. Returned quickly
7	2 inches	3 inches	4 inches	5 inches	Helium
8	Less than 2 in.	No change	2¾ inches*	5 inches	
9	2 inches	No change	4½ inches	4½ inches	
10	Less than 2 in.	3 inches	3½ inches	5 inches	
11	Less than 2 in.	4 inches	5½ inches	5½ inches	
12	2½ inches	3½ inches	5 inches*	7½ inches	Old target. Focal spot cracked.
13	Less than 2 in.	2 inches*	6 inches	6 inches	
14	Less than 2 in.	2¾ inches	5 inches	6 inches	
15	2¼ inches	No change*	4 inches	5½ inches	
16	2¾ inches	4 inches	7 inches	7 inches	
17	4 inches	5 inches	5½ inches	5½ inches	
18	5 inches	5½ inches	6½ inches	6½ inches	
19	Less than 2 in.	2 inches	4½ inches	5 inches	
20	Less than 2 in.	6 inches	6½ inches	6½ inches	
21	Less than 2 in.	No change*	2 inches*	4 inches	
22	2 inches	No change*	3½ inches*	7 inches	
23	4½ inches	5½ inches	6½ inches	7½ inches	
24	Less than 2 in.	No change*	No change*	4½ inches	
25	2¾ inches	2¾ inches	3½ inches	6 inches	

*Denotes re-spraying after testing tube.

REMARKS ON THE TECHNIQUE OF THE ROENTGEN EXAMINATION OF THE KIDNEYS

By W. S. LAWRENCE, M.D.

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MEMPHIS, TENNESSEE

THE technique which I am about to set forth in more or less laborious detail is by no means all my own, if indeed I can lay claim to any of it. It is mostly patched together from the oft-repeated suggestions of others. The only justification for the use of the little word "my" which frequently sets the rest of us on edge, is a certain grouping of the essential and indispensable factors of success, an exacting and persistent carrying out of every detail, together with full knowledge of, and an abiding faith in, the results that can be achieved when this work is done in the right way.

In doing kidney work our chief aim should be to produce plates showing the whole kidney outline clearly, unmistakably and without the aid of the imagination. Such a plate will possess the maximum of diagnostic value in every condition for which we are called upon to examine the kidneys. If the kidney substance shows clearly, denser substances will show much more clearly.

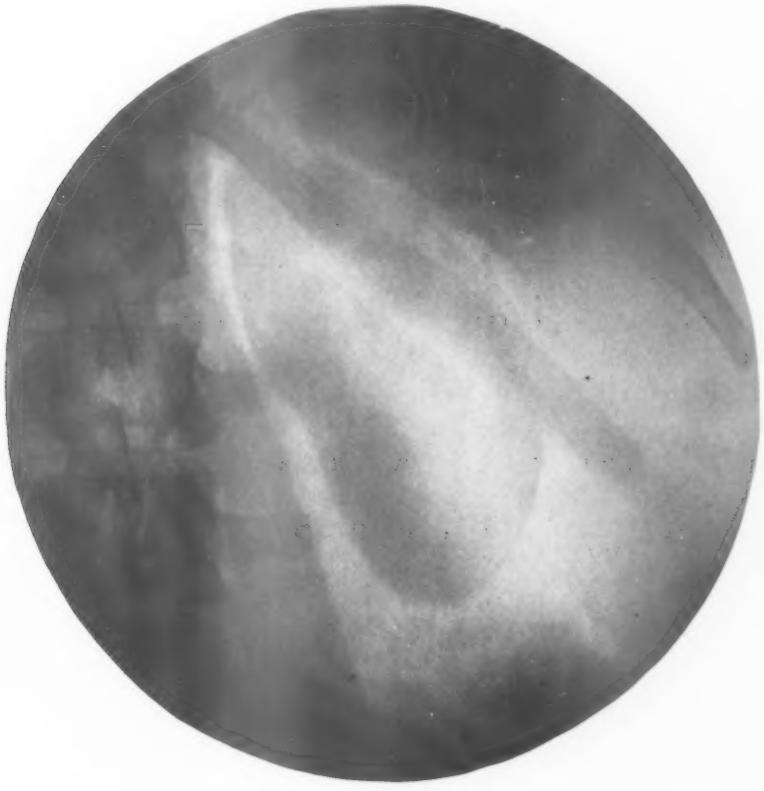

FIG. 1. NORMAL KIDNEY—RIGHT. NOTE CALICES UNINJECTED.

To make such plates with uniformity and

certainty there are certain points of technique which are absolutely essential. I will mention them somewhat in the order of their importance, though after the first, there is little choice as to which should be placed second, third or fourth in order of importance. Easily of first importance is the quality of the ray used; second, correct and adequate compression; third, preparation of the patient; fourth, control, real control, of the patient's respiration.

Kidney plates should be clear, soft and sharp, suggesting under-exposure rather than over-exposure. No black should anywhere appear on the plate. Such a plate cannot be made if the tube is excited by a current of high voltage. In actual practice I use a 3 to 3½ inch spark gap, 35 milliamperes, and an exposure varying from four to eight seconds depending upon the size of the patient. The time only is varied.

Second in importance and very much more difficult to obtain are proper compression of the patient and correct placing of the compression cylinder. For accuracy and ease of manipulation it is almost essential that the tube-stand be attached to the table, moving freely and easily at the side. With this type of table the tube-stand can be fixed so rigid that there is no possibility of any movement of the patient altering the position or angle of the tube. It is quite essential that the end of the compression cylinder be equipped with a convex aluminum cap. This sinks deep into the soft parts and displaces denser material; it also sometimes forces aside gas which may

Fig. 2. Normal Kidney Outline—Left Kidney.

be present in the colon. If the diameter of the cylinder is more than 5 inches at a distance of 13 inches from the target, the plate will be very little clearer than if no cylinder at all were used.

Again, in practice, I proceed as follows: The patient's knees are flexed. An 8 by 10 plate is placed crosswise under, say, the right side, so that its lower edge is about even with the umbilicus. The tube is then adjusted over a point midway between the umbilicus and the ensiform cartilage. The cylinder is then tilted between 5° and 10°, so as to point toward the right. At this angle it is lowered onto the patient slightly to the right of the median line, brought down with a fine adjustment device as tight as the patient will easily allow, and fixed so that it cannot be raised. The cylinder is now tilted about 10 to 25 degrees to point up under the ribs, and fixed in this position, and pushed up under the ribs as far toward the patient's head as he will allow, and fixed in this position. Finally, the tube and cylinder, sliding on the horizontal arm of the tube-stand, are moved as far towards the right as the patient will allow, and fixed in this position. This last movement will pull the ribs over to a considerable degree and it is necessary to instruct the patient not to turn toward the right side, and not to allow his back to slip on the table with an inclination to follow the movement of the tube. With everything fixed and rigid, the exposure is made.

Fig. 3. Normal Kidney Shadow—Left.

While the preparation of the patient is important, it is not essential in every case.

In patients who are not constipated or subject to gas formation in the colon, the examination may be made successfully without previous preparation; however, it is best in every case, when circumstances permit. This preparation consists of a thorough laxative the night before and an enema, as nearly as convenient, immediately preceding the examination. The importance of this cannot be too strongly emphasized in many cases. The kidney outline cannot be clearly brought out if there is a big gas pocket in the colon immediately over it.

In this connection a word as to the kind of patient who is most favorable for this work might not be amiss. The most favorable type is the rather fat, small individual. In such a case we have an ample bed of perinephritic fat much less dense than the kidney substance and supplying the contrast that is so desirable. For this reason even large, fat patients often prove easier than small, lean ones. But, large or small, fat or lean, the kidney outline can be brought out.

It has been customary to dismiss the point of the patient's respiration simply by saying, "instruct the patient to hold his breath during the exposure." If the doing were as easy as the saying, it would need no further comment, but it is not. Many patients find it quite difficult to stop breathing entirely, even for five or six seconds. Many think that they are holding their breath when they are not. Place a mirror on the abdomen of such a

Fig. 4. Kidney Injected—Catheter in situ. Note the Blurring Effect of Incomplete Respiratory Control.

patient, and while he is trying to hold his breath the reflection from the mirror will continue to sweep back and forth upon the ceiling. Such patients need instruction in holding the breath and close watching during the exposure.

The kidneys move more than we realize during respiration. This movement is from one-half to one and a half inches. A movement of only one-quarter inch will convert the shadow of a round stone into a long one, cause us to miss a small stone entirely, and completely obliterate any well-defined kidney outline.

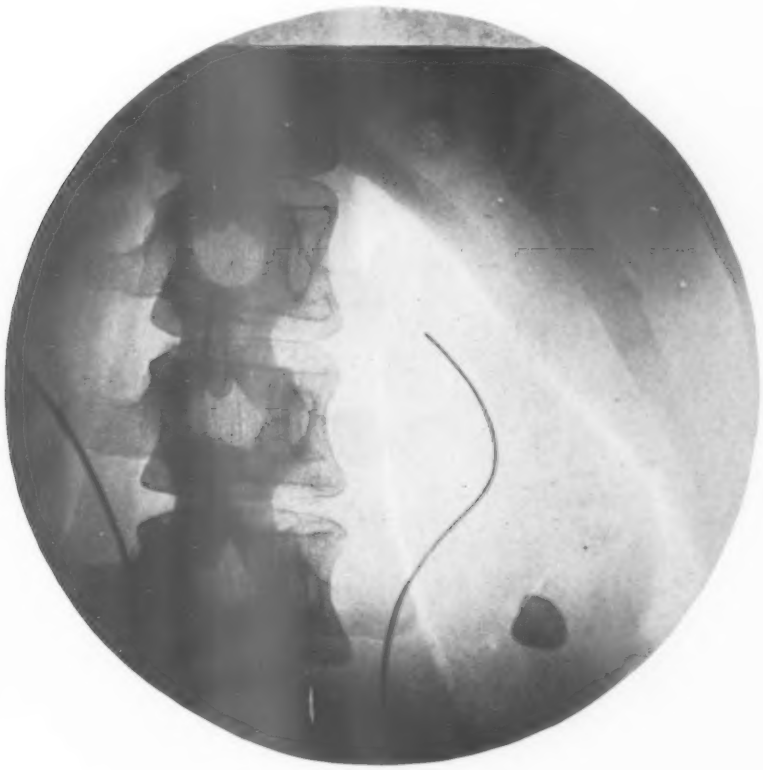

FIG. 5. KIDNEY OUTLINE, WITH STONE IN LOWER POLL. CATHETER IN SITU. NOTE THE SHARPNESS OF THE CATHETER SHADOW, INDICATING COMPLETE RESPIRATORY CONTROL.

SUBPHRENIC PNEUMOPERITONEUM*

Produced by Intra-uterine Insufflation of Oxygen as a Test of Patency of the Fallopian Tubes in Sterility and in Allied Gynecological Conditions

By I. C. RUBIN, M.D., F.A.C.S.

NEW YORK CITY

THE production of pneumoperitoneum by the method of insufflating the uterus with oxygen is intended to serve the specific purpose of testing the patency of Fallopian tubes. When the tubes are patent the gas passes into the peritoneal cavity, establishing an artificial pneumoperitoneum. This is detected by fluoroscopic examination. When occluded, the gas fails to reach the peritoneal cavity. In this failure to establish a pneumoperitoneum by the uterine route is furnished a fact of diagnostic value important particularly in the problem of the sterile woman.

Comparison of the Abdominal and Uterine Method of Producing Pneumoperitoneum.—This method cannot enter into competition with the production of pneumoperitoneum by abdominal puncture because of certain natural and pathological limitations. 1. It is obviously limited to women. 2. It is not applicable to all women, particularly the unmarried. Conditions such as pregnancy, menstruation and pelvic inflammation contraindicate for the time being its use. The method by abdominal puncture may be employed in the presence of nearly all these conditions without regard to uterine function. In cases where the uterus may be properly insufflated and the tubes are patent, it is of course possible to fill the peritoneal cavity with any desirable quantity of oxygen, in which case it may also serve as an aid in general abdominal diagnosis. This I have done in several cases at the request of colleagues in the medical and surgical services of Mt. Sinai Hospital. It may only be mentioned here that it can be done very simply without occasioning any appreciable sense of discomfort to the patient and involves no special surgical experience. It is not my purpose to advocate it either to substitute or to supplant the abdominal puncture method for general abdominal diagnosis. I am interested chiefly and practically in the aid it may render in clearing up the etiology of sterility in women.

In the problem of sterility a negative result is of equal importance with a positive result. Both prognosis and therapy depend upon whether Fallopian tubes in any given case of sterility are open or closed. I have elsewhere [1] pointed out that if we could demonstrate beforehand that the tubes are occluded a great many operations on the cervix of the uterus would not be undertaken. Instead of operating in such case upon the lower end of the uterus with a fruitless result, the patient remaining sterile and hoping against hope of becoming a mother, proper therapy would consist in immediately opening the abdomen with the object of freeing the tubes and doing some adequate plastic operation. Such operations have not infrequently resulted in curing sterility. Whether or not this type of operation is consented to, we are at least in the position to tell the patient from the very outset what her chances are for becoming a mother. Much time may be saved for those women who would gladly submit to a corrective operation at the very beginning were we in a position to locate the obstacle to conception at the true portion of the genital canal.

A word as to the *limitation of the abdom-*

[1] *Journal American Medical Association*, Sept. 4, 1920. Paper read before the Section of Obstetrics and Gynecology at the seventy-first session of the American Medical Association.

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

inal puncture method and its ability to demonstrate patency or occlusion of the tubes. It has been possible to outline the uterus, tubes and ovaries, inclusive of tumors of these organs and inflammatory conditions in the pelvis, by forcing the oxygen through the abdominal puncture into the pelvis in the extreme Trendelenburg posture. In a very limited number of instances one may be fortunate enough to succeed by this method in demonstrating the fimbriated end of both tubes distinct from the ovaries and the uterus. In the abscence of adhesions one might assume them to be normal. In the presence of tumor masses it is not so easy to distinguish between the tube and ovaries, nor are we always fortunate enough in separating the shadows of distorted and dislocated tubes from adherent and overlying ovarian tumors, or from pelvic abscesses and tumors of the uterus. One need but recall in this connection the difficulty of distinguishing structures in pelvic inflammations when the abdomen is opened. Also the demonstration of bilateral masses by the shadowgram does not preclude actual patency of one or both tubes. It is absolutely possible to determine this fact by the method of intra-uterine insufflation of oxygen. I have on several occasions been able to demonstrate patency of the tubes in the presence of bilateral adnexal masses and at the same time establish that the lesion involved the ovaries alone. If in the presence of pelvic masses the gas fails to produce a pneumoperitoneum it may be safely concluded that the tubes are diseased and occluded at some point of their lumen.

Whether or not gross lesions in the pelvis may be more accurately outlined and interpreted by pneumoroentgenograms than by physical examination, *the matter of patency or non-patency is specifically established by the patency of the tubes to oxygen.* This point has hitherto been a matter of clinical speculation defying the skill of the expert in physical examination. The only way by which this fact could formerly be established was by actual laparotomy with inspection of the tubes, palpation, probing them with a sound and inflating them from the fimbriated end, a practice advocated notably by English gynecologists.

The value of the method as a practical test in cases of sterility may perhaps be illustrated by the following two cases:

Case I. A patient married three years and sterile; upon pelvic examination she was advised to be operated, and a dilatation of the cervix, curettage and stem pessary insertion were subsequently performed. Four days following this operation I was requested to test the patency of her Fallopian tubes. The method employed by me resulted in failure to establish a pneumoperitoneum. Laparotomy the same day revealed the fact that both tubes were closed at the fimbriated end. They were only slightly distended, their walls were flaccid and they were surrounded by soft, cobweb adhesions—in other words an old standing bilateral hydrosalpinx. The operation on the cervix in this case was certainly fruitless and could have been avoided by a preliminary examination with oxygen.

Case II. A patient married five years, sterile, no pelvic lesion demonstrable to account for the sterility. Insufflation of the uterus with oxygen on three occasions (with and without pressure control) failed to establish a pneumoperitoneum. She was advised to have a laparotomy performed in the endeavor to remedy the occlusion. This advice she apparently did not heed because some months later she had a curettage and Dudley operation, following the advice of a physician who assured her that to become a mother all she needed was to have her womb "stretched." The lesion in her case could not have been very pronounced at any time, eluding detection by the palpating finger, because the operation was performed by a gynecologist of considerable experience and one who must have concurred in the opinion of the general practitioner.

Safety of the Method and Advantages Over Exploratory Laparotomy.—Notwith-

standing theoretical objections, all of which I have carefully considered in first contemplating the method, it has proved in my hands an absolutely safe procedure. Thus far I have had occasion to employ the method in 150 cases. As some of the cases were re-examined for purposes of corroboration, the total number of examinations was 170. In no case was there any evidence of injury or of infection. The cases were all observed carefully for a period of several months.

Compared to an exploratory laparotomy for the specific purpose of determining the patency of Fallopian tubes, it has several superior advantages, not the least of which is the economic advantage of saving the patient from the usual period required for post-operative convalescence. The method may be employed as a routine measure in one's office and the patient loses no time in laying up, has none of the discomforts and morbidity attendant upon a laparotomy. I am not discussing the question of mortality, assuming that that is practically nil in exploratory surgery. The method proposed by me should never result in mortality. The one theoretical possibility of fatality resulting is offered by the occurrence of embolism. This I have satisfied myself, by experimentation upon the extirpated uterus and in the living animal by direct intravenous insufflation of oxygen, can be dismissed from practical consideration. This accident and that of infection have not occurred in my series of cases, and infection should never occur when the procedure is adopted in properly selected cases and for the specific object of testing the patency of Fallopian tubes.

Contraindications.—The uterus should not be insufflated with oxygen in the presence of pus pouring down from the cervix, in the presence of fever caused by pelvic inflammation, in the presence of acute bartholinitis, urethritis or vaginitis. It is not advisable to use it during menstruation or any irregular uterine bleeding.

Ideal to be Sought in the Use of the Method.—By this I mean that we should be able to employ it in the office as a routine procedure for diagnosis comparable to cystoscopy and ureteral catheterization, occasioning no more and possibly less pain and discomfort than obtains in the urological examination. One of the chief aims is to make the method tolerable to the patient. It should not require the use of an anesthetic. So far I have not had to resort to any. It should take a short time, a minute or two, at the most three. It should be followed by very slight symptoms and not interfere with the daily duties and usefulness of the patient. To accomplish this, it is necessary to produce what might be called a miniature pneumoperitoneum confined in the erect posture to the subphrenic space. The smallest amount of oxygen sufficient to show distinctly through the fluoroscope should be injected. I have found in developing the method that from 100 to 150 c.c. of oxygen suffice to establish the subphrenic pneumoperitoneum. The most favorable time for the test is in the post-menstrual stage, in the interval of apparent functional quiescence.

Technique.—The armamentorium consists of an oxygen tank connected with a water bottle, the rubber stopper of which is perforated at three points through which bent glass connecting tubes pass. (Fig. 1.) One of these glass tubes is connected directly with the oxygen tank and dips down below the water level. The two other glass tubes dip down one or two inches and do not reach the water level. One of these is attached by rubber tubing to a mercurial manometer and the other is attached in the same way to the metal cannula. This metal cannula is of the Keyes-Ultzman type and is perforated at the tip by several small apertures. (Fig. 1.) A single tenaculum or bullet forceps, a uterine sound, a dressing forceps and bivalve vaginal speculum complete the apparatus. A rubber urethral tip is fitted over the metallic cannula to a point 1½ to 2 inches away from the cannula tip.[2]

[2]Recently at the suggestion of my friend Dr. E. D. Oppenheimer I have adopted a simple device for measuring the volume of the gas and hope to describe it in the near future. It is made by courtesy of Wallace & Tiernan, 349 Broadway, New York City.

The volume of gas entering the uterus and eventually into the peritoneal cavity may be measured by displacing water and taking the time—interval measured in minutes. The average amount of water displaced should not exceed 250 c.c. per minute nor be less than 50 c.c. per minute. The rate of flow determines the pressure. The rapidity with which this rises I have found to be best limited to a 10:15 second interval for 100 millimeters mercury. At this rate from approximately 250 to 150 c.c. of oxygen is released per minute. This is determined previously by pinching the rubber tubing with the needle valve shut, allowing the gas to pass through at the rate fixed by the water displacement. With the gas flowing at this rate it may now be introduced into the uterus. The cervix is wiped clean and painted with iodine. A single tenaculum hook grasps the anterior lip. The cannula is introduced into the uterus well above the internal os and the urethral rubber tip is pushed well into the external os so as to render it air-tight. The gas is allowed to escape during this maneuver through the needle-valve release; the pressure is therefore atmospheric. As soon as the cannula is well secured within the uterus the needle valve is closed, allowing the oxygen to be insufflated within the uterus. Almost instantly the pressure rises. When the cannula is fixed within the uterus the patient is raised in slight Trendelenburg position and the vagina is filled partly with water to show any escaping gas from the cervix. This is not always necessary and should only be done in doubtful cases.

Pressure Reading in the Case of Patent Tubes.—The mercurial pressure rises to at least 40 mm., more often to from 60 to 100, with a slight momentary fluctuation possibly at that point, when it drops quite sharply 20 to 40 or even 60 points, which latter level it maintains more or less until the cannula is removed. The time required for the pressure to reach its maximum point according to the recommendation as above described is usually 15 to 25 or 30 seconds. The rest of the time, say 30 seconds to 45 or 60 seconds, is allowed for actual inflow into the peritoneal cavity.[3] This will depend upon the time interval required for the initial rise to the maximum on the one hand and on the other upon the size of the individual.

If the individual is narrow-waisted and thin she does not require as much gas to produce the subphrenic pneumoperitoneum as would an ample-waisted patient. These

Fig. 1. The Apparatus Assembled. Note the Relief (Needle) Valve. This relief valve may be at any point in the outlet tube in case the tycos type of manometer is employed.

matters one can learn to gauge after some experience. No hard and fast rule can be laid down for these variations. At most they are slight and offer no difficulty. The average amount of oxygen required in a thin individual is from 75 to 100 c.c. In a stout woman it is well to use from 150 to 250 c.c.[4]

Pressure Reading in the Case of the Non-

[3]The siphon meter of the Wallace & Tiernan type records the volume passing through automatically.

[4]When CO_2 is employed the quantity may because of its rapid absorption exceed these figures several fold.

Patent Tubes.—The pressure rises steadily, reaching 200 within 30 to 45 or 60 seconds. The pressure should not be allowed to exceed 250. It is maintained at between 200 and 250 for at least another minute if possible. This can be done by regulating the needle valve to permit a slight escape of the gas. In my experience so far a pressure of 200 or more, provided the rate of flow does not exceed 250 c.c. per minute, proves fairly conclusively the presence of tubal obstruction. This may of course be within the uterus itself, the blockade being at the uterine ostiae of the tubes, or it may be at any point along their lumen. When the rate of flow exceeds 250 c.c. per minute the initial rise may occasionally read 200 mm. or more before the gas passes into the Fallopian tubes and thence into the peritoneal cavity. The physics thus expressed is only from practical tests. Exact computations have as yet not been made.

FIG. 2. SUBPHRENIC PNEUMOPERITONEUM. 250 C.C. OF OXYGEN INSUFFLATED THROUGH THE UTERUS AND FALLOPIAN TUBES. Diaphragm distinct on the right side; not visible on the left.

FIG. 3. SUBPHRENIC PNEUMOPERITONEUM. 1500 C.C. OF OXYGEN INSUFFLATED THROUGH THE UTERUS AND FALLOPIAN TUBES. Diaphragm distinctly visible on right and left sides. Abdominal viscera displaced to a considerable depth. For the purpose of demonstrating patency of the Fallopian tubes one-fifteenth of this amount is sufficient and satisfactory in the majority of cases.

SYMPTOMS. 1. *During the Oxygen Insufflation.*—The introduction of the cannula is attended in most cases with slight pain. Grasping the anterior lip of the cervix by the single tenaculum hook is noticed scarcely, if at all, by the patient. The actual insufflation in the patent cases seldom causes pain. When the initial pressure exceeds 100 the patient may complain of a sensation of fullness or bearing down or occasionally she may feel as if she were unwell. In the nonpatent cases with the pressure rising to 200, cramps are occasionally complained of, now in the suprapubic region and now in one or both sides. Since the time required for insufflation is the short interval of one or two minutes, practically every case can tolerate it. I have had practically no failure due to intolerance during the examination. A ner-

vous patient will sometimes defeat the completion of the test, but even she can be reassured and will submit to it at another time. That will happen once in 50 or 100 times.

2. *After the Oxygen Insufflation; Fluoroscopy. In the Patent Cases.*—Inasmuch as the patient is instructed to stand up immediately on withdrawing the uterine cannula, the oxygen gas rises almost instantaneously to the region of the diaphragm. It occupies the subphrenic space for a depth of ¼ to 1 inch or more depending upon the amount insufflated. (Fig. 2.) Within two or three minutes if not sooner (just as soon as the patient can be set up before the fluoroscopic screen) the transparent "gas" area may be seen under the diaphragm. The liver on the right side is seen displaced in a downward direction. Not infrequently the gas may be localized to one or the other side, but as a rule the diaphragm may be seen lifted above the underlying abdominal viscera from right to left. It is discernible as a transverse septum and is unmistakable. When the subphrenic pneumoperitoneum is not at once visible the patient is instructed to lie on her right or left side for a few minutes, after which the gas will show clearly on one side or the other.

It is not necessary for the purpose of testing the patency of Fallopian tubes to fill the peritoneal cavity with a large volume of gas in sufficient quantity to "visualize" the abdominal viscera, as in Figure 3. The symptoms in such a case are rather distressing and this is obviated by reducing the pneumoperitoneum to its diminutive. With 75 to 100 c.c. of oxygen under the diaphragm the secondary symptoms are almost negligible. Slight sticking pains between the shoulder-blades or in the shoulders themselves are noticed by the patients. There is no abdominal distress, and if at all present it amounts to a slight sense of discomfort about the diaphragm. The vast majority of the patients leave the office and continue in their ordinary daily routine. Some patients may require to lie down with feet elevated for a few hours. As, according to Alvarez, carbon

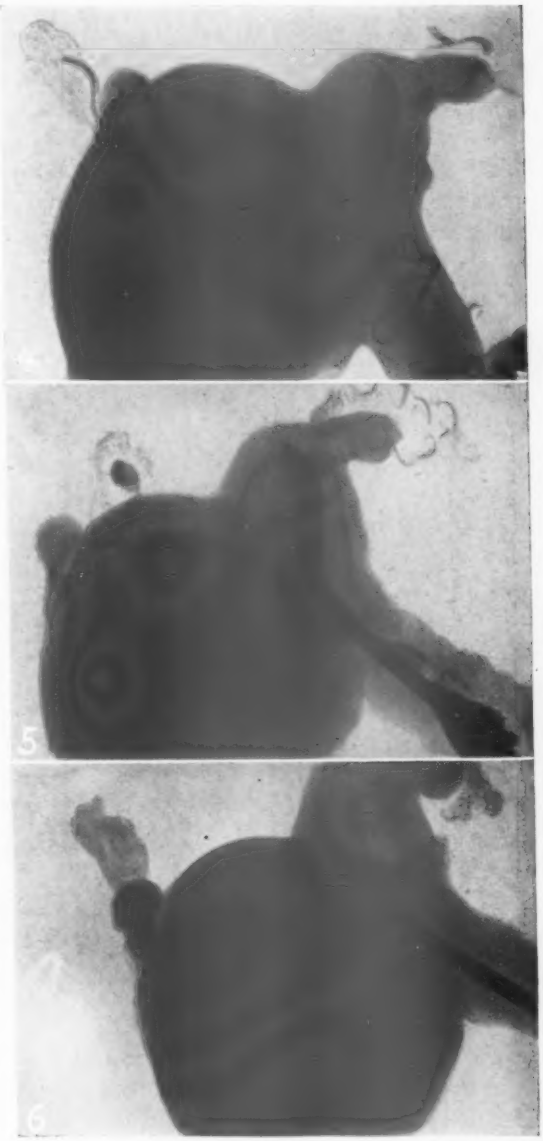

FIG. 4. A BICORNUATE UTERUS. Thorium injection. The tubes are closed by a ligature at the fimbriated end. Note the definite clubbed outline of the tube at point of ligature and the narrow caliber of the intramural portion.

FIG. 5. THE SAME SPECIMEN AS IN FIGURE 4. Skiagraphed during thorium injection with the ligature removed allowing the solution to escape through the fimbria. Note the irregular and overlying shadows.

FIG. 6. SKIAGRAPH OF THE SAME SPECIMEN AS IN FIGURES 4 AND 5. Oxygen injection. Note the faint shadows in the horns of the uterus and the absence of any contrast shadows within the Fallopian tubes.

dioxide gas is more rapidly absorbed than oxygen, it may be well to use it and reduce the secondary symptoms to a negligible minimum.

Immediately on withdrawing the uterine cannula there may be a slight regurgitation of oxygen with a slight oozing of several drops of blood that is readily checked by a sponge applied to the cervix. It is negligible and gives no further trouble. By selecting the post-menstrual period for the test one can avoid even this slight oozing.

In the Non-Patent Cases.—Beyond the temporary discomfort produced by the insufflation there are no further symptoms. The cramps may continue for a minute or two or perhaps five and then subside. None of the referred shoulder pains are complained of and there is no epigastric oppression. The oozing is almost as slight as in the case of patent tubes; the oxygen regurgitation may be more evident. The non-patent tube cases are perfectly comfortable after the test and leave the office to go about their duties as freely as before.

It is well to mention here that I have made it a rule to repeat the test at least once in the non-patent cases to check up the findings at the first examination. With the apparatus properly adjusted in each case the findings will be found to corroborate each other at the second test. Occasionally, however, there may be an error in technique which will invalidate the conclusion. Most scrupulous attention should be given the possible points of leakage along the entire apparatus.

FIG. 7. CASE OF ABLATED TUBES; LARGE UTERUS—40 C.C. OF OXYGEN INJECTED INTO THE UTERINE CAVITY. This is seen transversely pear-shaped. The speculum, cannula and Thomas pessary are also seen.

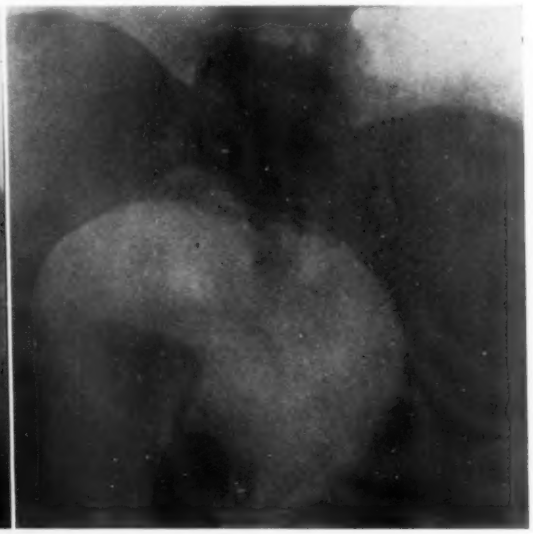

FIG. 8. SAME CASE AS IN FIGURE 7. 40 C.C. THORIUM INJECTED INTO THE UTERINE CAVITY.

While in the positively patent cases there may have been some regurgitation, nevertheless when this occurs and the gas does not enter the peritoneal cavity we are left in doubt and must, if need be, repeat the test several times. If regurgitation takes place each time it is highly probable that there is an obstruction within the uterus which is responsible for it. On the other hand, oxygen may escape from the cervix and a sufficient quantity nevertheless reach the peritoneal cavity as may be determined by the fluoroscope.

Anatomical Consideration in Relation to the Test.—The ideal case for the test is one in which there is no thick tenacious plug present, in which the external os is round

and intact, the uterus not sharply angulated. In such cases the cannula (ordinary size) enters easily and obturation is more perfect. When the uterus is sharply flexed forward or backward it is necessary to shape the cannula accordingly so that it may enter the uterine cavity to a point above the internal os. When the external os is gaping and torn as obtains in certain cases of relative or secondary sterility it may be necessary to secure better obturation by grasping the two lips of the cervix with a bullet forceps. The internal os, however, is intact even in these cases and as the cannula is introduced beyond it the ordinary cannula insures satisfactory obturation. A mucus plug should be cleaned out and the cervical canal painted with tincture of iodine.

When the external os is narrow it is necessary to use a cannula of correspondingly smaller caliber or it may be advisable first to dilate it gently to proper width.

Occasionally obstruction is encountered near the internal os. Here of course the test cannot be carried out. This is an incidental finding which has particular significance in the problem of sterility for that given patient. In such case it is first advisable to overcome the stenosis by proper dilatation and then later on the oxygen insufflation may be tried. I have had two such cases in my series.

Uterine Insufflation of Oxygen Compared to Intrauterine Injection of Solutions Opaque to the X-Ray as a Test of Tubal Patency.—My experience with the injection of solutions opaque to the *x*-ray included collargol, thorium and bromide. All of these are useful when the tubes are occluded. (Figs. 4 and 8.) When the tubes are patent the roentgenograms are not uniformly satisfactory because the solution escapes into the peritoneal cavity and not enough of it is left to show in the tube lumen. (Fig. 5.) Collargol leaves deposits in the tubes which may or may not be absorbed. Thorium and bromide in solution do not leave precipitates. Peritoneal irritation by chemical action with consequent adhesions is a possibility to be borne in mind. Whether or not this may be the case, an objectionable feature to the use of the solutions is the uterine colic, accompanying and following the injection. Patients do not tolerate this so well. In this one respect the oxygen insufflation has a particularly superior advantage. Any residual oxygen within the uterus is immediately expelled with the removal of the cannula. The other advantage of no less importance is that the oxygen is readily absorbed by the tissues and does not leave irritative precipitates. Only exceptionally will one encounter a uterus that may be called irritable to the oxygen. It is more apt to be in a very nervous woman. In my experience with the oxygen insufflation I have succeeded in completing the test in every case, although in two instances I had to defer the test for another time owing to apprehension on the part of the patient. It is conceivable however that in cases of endometritis and perimetritis of more recent date the uterus will be tender to the manipulation.

Oxygen does not show in the tubes when patent. In the anatomical specimen it may show very faintly in the skiagraph (Fig. 6) when the tubes are ligated at the fimbriated end but not in sufficient density to appear in the living subject where the contrast is obliterated by neighboring shadows, etc. Occasionally in a case where both tubes have been removed and the uterine cavity is large, having a capacity of 40 to 50 c.c., one may succeed in getting a good outline picture with oxygen. I have had one such result. (Fig. 7.) Our experience in attempting to demonstrate the oxygen in uteri during the injection with the exception of this one case has so far not been satisfactory although we have not made a persistent effort in this direction.

Conditions in which the Intra-uterine Oxygen Insufflation Method Has Been Found Useful.—1. Primary and absolute sterility of several years' duration with no gross lesions ascertainable. This is the ideal group for the test.

2. Sterility of long standing where pelvic

masses are palpable and clinically diagnosticated as fibroids or "chronic diseased adnexa." The test shows whether or not the tubes are open.

3. Cases in which one tube was removed for inflammatory disease or for unilateral ectopic to determine the normality of the lumen of the residual tube.

4. Cases in which there is a history of an attack of appendicitis with peritonitis in the premarital or postmarital state to exclude tubal occlusion by a residual adhesive peritonitis.

5. Cases following a pelvic exudate or abscess with or without operation and where apparent resolution has taken place and yet sterility is complained of.

6. To test the probity of the tubes in cases where tubal ligation was done with the object of permanent sterilization.

7. To test the continuity of the genital canal in cases where the conservative operation of myomectomy, single or multiple, was done in the hope of relieving sterility.

8. To test the result of plastic operation on the tubes in cases of bilateral salpingostomy.

A detailed account of these results will be taken up in a clinical consideration of the problem of sterility.

CONCLUSION

The method of intra-uterine oxygen insufflation to produce an artificial pneumoperitoneum establishes the fact of patency or occlusion of Fallopian tubes. Under manometric and volumetric control it is a scientific, diagnostic procedure and may be employed with safety to determine the mechanical factor involved in the etiology of female sterility. For this purpose it obviates the necessity of surgical exploration and is specific.

As the fact of tubal patency is in most cases primarily a matter for speculation, its scope for general abdominal diagnosis as compared to that offered by the direct abdominal puncture metohd is necessarily limited. In cases where the tubes are patent, however, a pneumoperitoneum of any size may be produced by the uterine route.

For the definite object of establishing tubal patency by intra-uterine insufflation, only a diminutive amount of gas is necessary because the result desired is to produce a localized subphrenic pneumoperitoneum which shall be followed by scant if any symptoms. The vast majority of the patients tolerate this method very well and it may be employed as a routine office procedure. The use of carbon dioxide instead of oxygen will diminish the symptoms following insufflation almost to a vanishing point. It is well however to bear in mind the primary object of the test and to apply it only in cases properly suited for its use. In these it has proved of great diagnostic and prognostic value.

In 150 cases, with a total of 170 examinations, there have been no untoward sequelae.

THE DETECTION OF RETROPERITONEAL MASSES BY THE AID OF PNEUMOPERITONEUM

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THE wider use of pneumoperitoneum as an aid to radiological diagnosis of abdominal conditions is fast bringing the subject from the stage of generalities to that of more special methods of examination.

The number of experiences encountered, even in the fifty pathological cases which we have had, is so large that it would seem more advisable and probably be more profitable to consider one of the groups into which these cases fall rather than to undertake a discussion of the subject in general. I shall, therefore, confine this paper to one of the groups of cases in which we have found this method of great aid; I refer to the detection of retroperitoneal masses.

FIG. 1. RETROPERITONEAL POSITION. Patient Prone. Chest and thighs supported on two blocks, allowing the abdominal wall to sag freely without pressure.

Early in our experience with pneumoperitoneum, we encountered a case which proved to be of great value to us in developing a technique for the detection of retroperitoneal masses. I shall outline the case, as it presented itself. B. C., a well developed, colored male, age twenty-six, presented himself, with a slightly tender, very hard, smooth mass in the lower right quadrant of the abdomen. The case was the occasion of some dispute among the staff, as to whether the mass was attached to the kidney or not, and a pneumoperitoneum examination was made to try to determine its origin. By the ordinary antero-posterior plate, it was found that the mass was entirely free from both kidneys, and that it extended downward to the pelvis and across the midline, causing nearly as large a mass, as yet undiscovered, on the left side. In an effort to determine the relation of this mass to the ureter an injection of thorium was made into the kidney pelvis and a plate was made showing the smooth gentle curve of the ureter. A second plate was then made while exerting upward and inward pressure on the mass with a cone, and the radiograph showed a distinct kinking of the ureter, suggesting that the mass was retroperitoneal and that the ureter passed anterior to it. Destruction of the bodies of the 4th and 5th lumbar was noted, and the possibility of the mass being a tuber-

cular abscess was at once considered. In an effort to demonstrate the origin of the mass more clearly, the patient was examined in a prone position (Fig. 1), chest and thighs supported on two blocks taking all pressure leaving a clear space between them and the retroperitoneal structures. The liver is attached by the triangular ligament to the diaphragm, and drops forward also, to a greater or lesser extent in different individuals ac-

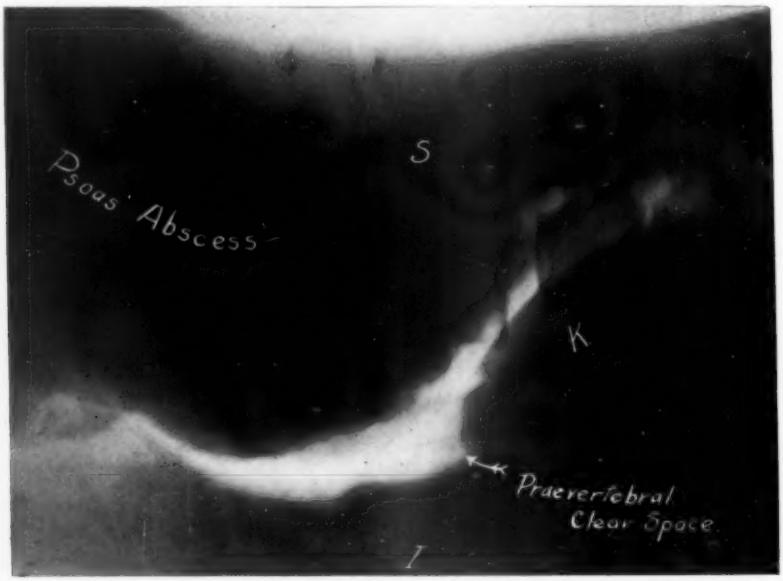

Fig. 2. Psoas Abscess Shown in the Retroperitoneal Position Encroaching upon the Praevertebral Clear Space.

off the abdomen and allowing the anterior abdominal wall to sag freely between the two supports. The retroperitoneal character of the mass and its complete separation from the kidneys was then clearly shown (Fig. 2), and since the mass originated in the area of destruction of the lumbar spine, the diagnosis of psoas abscess was made, which was confirmed by subsequent developments.

Since this prone position demonstrated the retroperitoneal origin of the tumor mass so clearly in this case, it was not long before we made a closer examination of its possibilities in other cases. A moment's consideration of the anatomical arrangement in this position may serve better to illustrate the cases which are to follow. (Fig. 3.) It will be noted that if the patient is suspended on two blocks, so as to take all pressure off the abdomen, the belly wall will sag down and all of the intra-abdominal organs with mesenteric attachments will fall forward

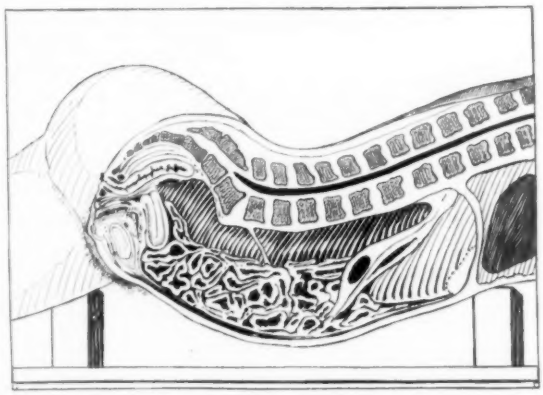

Fig. 3. The Patient, Previously Overdistended, is Supported upon Two Blocks, allowing the anterior abdominal wall to sag down freely. The intestines and all organs with mesenteric attachment have fallen forward, leaving a praevertebral clear space. Any retroperitoneal mass will encroach upon this clear space.

cording to the location of this attachment, forming a triangular shadow with the apex at the diaphragmatic attachment. If the individual is normal this space should be clear; if

a retroperitoneal mass is present, this space is encroached upon. Figure 4 shows in a gross way the appearance of a normal individual in the retroperitoneal position. Note that the intestines and all structures with mesenteric attachment have fallen forward and that the prevertebral space is clear and not encroached upon. The liver shadow is seen with its diaphragmatic attachments.

To illustrate the value of this position let us proceed to the second case.

J. M., white, male, age thirty-two, presents on examination a large tumor mass on the left upper abdomen; not painful and moving only slightly, if at all, with respiration. On inflation the mass was seen to have no connection with the anterior abdominal wall, although it did protrude well forward and was represented by a shadow in the middle of the abdomen. An antero-posterior examination revealed the extent of the mass to be even greater than supposed and it

Fig. 4. Radiograph of a Normal Individual in the Retroperitoneal Position. Intestines and organs with mesenteric attachment have fallen forward, leaving clear praevertebral area. Encroachment upon this space by a mass originating in the retroperitoneal tissues can be clearly seen.

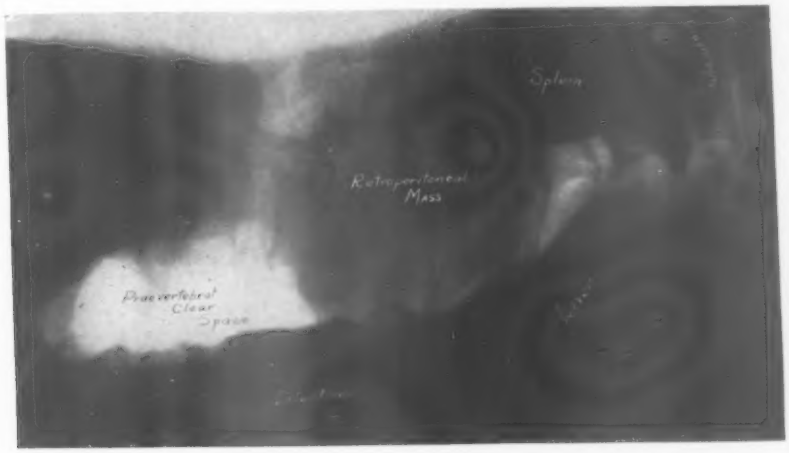

Fig. 5. New Growth of Left Kidney Seen in the Retroperitoneal Position to Encroach upon the Praevertebral Clear Space.

seemed to go down into the pelvis. The liver was shown to be uninvolved.

An examination in the lateral position showed the spleen clearly separated from the mass but the left kidney could not be definitely outlined. In an effort to determine whether the left kidney was involved in the sition with Figure 5 as a result. The intestines, stomach and all organs with mesenteric attachment have fallen forward. The liver has dropped exceptionally far forward and the only organ which still remains in place is the spleen, which probably is adherent somewhat to the diaphragm, and which may also

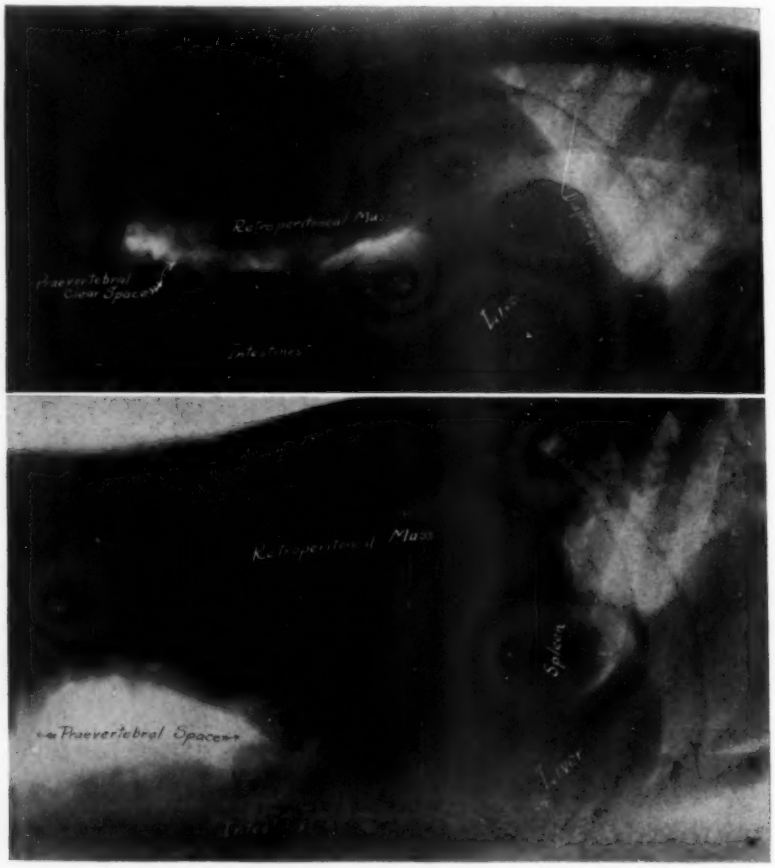

Fig. 6. (*Above*) Perinephritic Abscess Showing Diffuse rather Extensive Encroachment of the Mass upon the Praevertebral Space.

Fig. 7. (*Below*) Large Sarcoma of Kidney Shown in the Retroperitoneal Position to Encroach upon the Praevertebral Clear Space to a very Considerable Degree.

mass, the ureters were catheterized and 20 c.c. of thorium nitrate injected with the result that nothing more than a misshaped shadow appeared within the tumor mass.

To rule out a possible origin from the large bowel, a barium enema was given. The colon was perfectly normal and encircled the tumor without in any way being attached to or compressed by the mass. Lastly, as a final step in the pneumoperitoneal examination, the patient was put in the retroperitoneal po- have been prevented from displacement by the shelf-like projection of the mass. The mass itself can be seen taking origin among the retroperitoneal tissues and extending forward to encroach upon the prevertebral space. Diagnosis of a new growth involving left kidney was made.

A third instance illustrating the advantage of this position will be seen in the case of M. S., white, female, age thirty-three, who presented on examination a palpable mass in

the right lower abdomen which was very tender both on abdominal palpation and over the back, and was thought to be a movable kidney. Pneumoperitoneum examination revealed a diffuse, hazy mass on the right side below the liver and widely separated from it. Examination in the retroperitoneal position made by the aid of pneumoperitoneum was made (Fig. 6) and a rather extensive obscurity of the retroperitoneal tissues was seen. The liver and all organs with mesenteric attachment have fallen forward, but the spleen is adherent and seen in its position in contact with the diaphragm. The mass encroaches upon the prevertebral space but seems to be more diffuse. Psoas abscess was considered but no carious vertebrae could be found. Tumor of the kidney was thought of, but a plate showing clearly the kidney outlines was obtained and the radiological diagnosis was a probable perinephritic abscess. Operation confirmed this diagnosis.

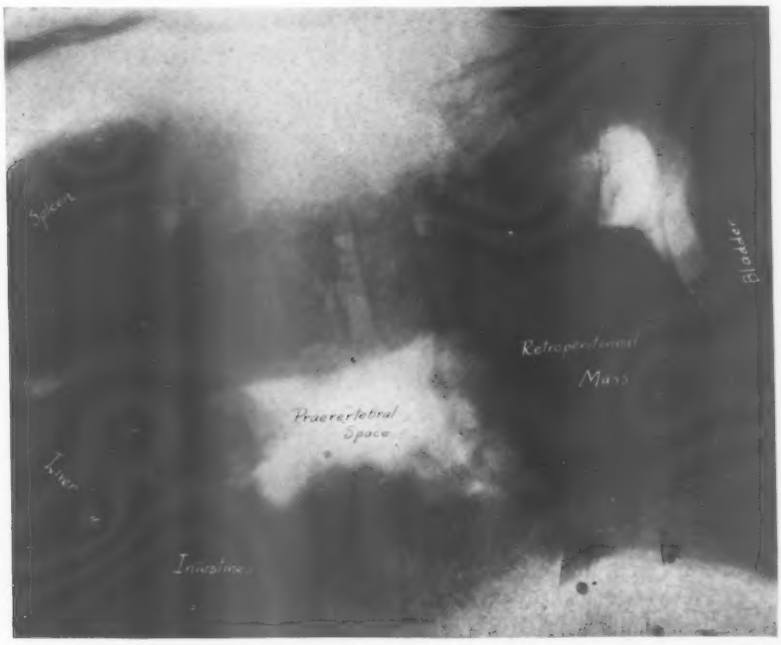

FIG. 8. RETROPERITONEAL CARCINOMA SECONDARY TO CARCINOMA OF THE BLADDER SEEN ENCROACHING UPON THE PRAEVERTEBRAL SPACE. Note the slightly rotated position necessary when dealing with retroperitoneal masses in the pelvis.

The fourth case in the study of this method of examination, was likewise very interesting. J. V., colored, male, age nineteen, presented besides an enormous abdominal tumor occupying the entire left side of his abdomen, innumerable small nodules under the skin all over the body. The abdominal mass seemed to move slightly with respiration and on first examination was thought to be the spleen. Antero-posterior view at once showed the extent of the mass and showed its separation from the spleen. The lateral view also showed the mass to be very extensive, with areas of irregular density and an oval, more or less smooth outlined mass at the top. A small stringy-like shadow resembling the kidney pelvis was seen in the midst of the mass and on looking up the records of the case it was found that ten months previously there had been an injection of his kidney pelvis made with thorium nitrate. In this plate his kidney outline showed also very well, but since his complaint was the same it is quite probable that this was at the inception of his disease. The diagnosis was not made at that time. Finally examination was made in the retroperitoneal position (Fig. 7) and a large retroperitoneal mass was found projecting forward into the prevertebral

space and almost obliterating it. Diagnosis of tumor of the left kidney was made. Operation and pathological section established the diagnosis of sarcoma of the kidney.

When the pathological process is low down, so that the shadow of the mass falls below the shadow of the innominate bones, the patient, still in the retroperitoneal position, must be rotated slightly towards the side of the tumor, in order to get a view unobstructed by the crest of the ilium.

The following case presents quite clearly the use of the retroperitoneal method of examination in tumors low down or in the pelvis. F. L., white, male, age sixty, presented upon examination a large rounded tumor mass, arising just over the symphysis, and extending to the umbilicus. With frequent voiding of small amounts of urine and tenesmus, the patient looked very similar to one suffering from urinary retention from an hypertrophied prostate. Pneumoperitoneum examination was made and a large mass about the size of a child's head was seen almost completely to fill the pelvis. A dark shadow just above the symphysis was taken to be the collapsed bladder, and on injection this proved to be the case; the mass was separated from the bladder. A barium enema was given and the sigmoid was seen to run over the mass but was unobstructed in its course, and give the impression of a retroperitoneal mass, which had in its growth merely pushed the large bowel forward.

The patient was examined, slightly rotated in the retroperitoneal position (Fig. 8) and a large retroperitoneal mass was found, widely separated from the bladder. No bone destruction of spine or pelvis was found. Cystoscopic examination of the bladder was made and a carcinoma of the bladder was found. Diagnosis of retroperitoneal carcinoma, secondary to a carcinoma of the bladder was made.

To outline briefly the essentials for a satisfactory retroperitoneal examination:

1. It is especially essential when this examination is to be undertaken, to clean out the bowels well, using vegetable cathartics.
2. The patient should void his urine just before examination.
3. He should be given little if any food just prior to the examination.
4. He should be *over-distended* with the inflating medium.
5. He should be sufficiently well supported to exert no pressure on the interabdominal contents.

We have to date used this position in the detection of retroperitoneal masses with continued satisfaction and feel that it will ultimately be of great value for this purpose.

DISCUSSION FOLLOWING SYMPOSIUM ON ARTIFICIAL PNEUMOPERITONEUM

[In addition to Dr. Rubins' and Dr. Sante's articles in this issue of the JOURNAL, the Symposium includes the following: *Pneumoperitoneum of the Pelvis: Gynecological Studies,* by James G. Van Zwaluwenberg, M.D., January issue, p. 12. *Pneumoperitoneum as an Aid in Differential Diagnosis of Diseases of the Left Half of the Abdomen,* by A. F. Tyler, M.D., February issue, p. 65. *The use of CO_2 in Producing Pneumoperitoneum,* by Walter C. Alvarez, M.D., February issue, p. 71.]

DR. LEOPOLD JACHES. The roentgenologic method in connection with Dr. Rubin's work was developed by my associate, Dr. Bendick, and I have seen a relatively small proportion of these cases, but I can assure every roentgenologist here that it is a very easy procedure, that it doesn't take much time. There is no fuss about it. We have very frequently been able to do one or two or three cases between other fluoroscopies. There is absolutely no fuss at all.

I am not as pessimistic as Dr. Rubin is with regard to the possibility of determining which tube is patent and which is closed. It should

not be very difficult to do so fluoroscopically during the time of the inflation.

We have not yet at the hospital a fluoroscope appropriate for this work, but as soon as our Dessane bonnet arrives we shall investigate this phase of pneumoperitoneum.

Dr. J. W. Hunter. I should like to inquire of Dr. Van Zwaluwenberg if pregnancy can be diagnosed by the pneumoperitoneum method unless the head or some of the bones of the fetus are shown on the plates. The reason I ask that is because I did not notice any on the slide which he showed us.

Dr. James G. Van Zwaluwenberg. With regard to the demonstration of pregnancy without the actual demonstration of bony parts of the fetus, I am very optimistic that we shall be able to do this because there must be differences in development and enlargement of the uterus from those of pathological enlargements. We haven't seen a great many of these cases, and I don't know positively whether that is so, but so far we have have had no myomata of the uterus which looked anything at all like pregnancy, and we have plates of one case whose last menstruation was six weeks before the examination, one which Dr. Peterson insisted was pregnancy, and the changes in the uterus are altogether characteristic. That is his opinion. I think there will be very little difficulty in differentiating the distortion of the uterus by a myoma or other enlargement from that of a pregnancy.

To Dr. Stewart, we owe a great obligation, because the idea of the work was directly suggested by some of the plates he showed at Saratoga. The objection he has met, we also are meeting. The Department of Gynecology has been the subject of considerable ridicule for using this method, on the ground that they should be able to make all their diagnoses without it. As a matter of fact, the gynecologist usually knows pretty well what he is going to find when he opens the pelvis, but the fact remains that sometimes he doesn't, as Dr. Rubin's case, in which there were double pus tubes which were not suspected, illustrates. The same sort of thing has happened in our experience. I doubt if the method will ever become routine. We are doing it routinely now until we have established a basis for our opinions, which, at this time, aren't worth a great deal, but I have great hopes that some system of standards can be established which will make this method of real use.

Dr. L. R. Sante. I noticed that Dr. Rubin referred to the pneumoperitoneum showing more on one side than on the other in these cases, and I would like to offer the following as a possible explanation: The mesentery of the small intestine, as we know, is attached on the posterior wall of the abdomen in an oblique position. I wonder if this does not act as a wall, thereby confining the oxygen more on one side of the abdomen or the other depending upon which tube is patent.

Dr. Rubin (closing). I am glad to have heard the explanations of the appearance of the unilateral pneumoperitoneum. I am quite free to say I did not think of all those things. It may very well be, though, because in the beginning we had the patient get off the table on one side or the other, and it is very likely that that occurred, but lately we have had the patient sit bolt upright, so that the explanations given could not be true in that event, and so some other explanation may be necessary. Dr. Sante's suggestion of the slanting mesentery may be true in some cases. On the other hand, as Dr. Stewart explained, the gas takes the path of least resistance and is influenced by the weight of the viscera. It may very well be that sometimes the stomach is heavier than the liver. As a rule, the liver is heavier than the stomach.

About the contra-indications: I would like to repeat them again. The presence of pus in the genital canal, urethra, vagina or cervix, and the presence of fever due to pelvic inflammation are contra-indications. Even though there is an inflammatory process, however, if there is no fever, that lesion is quiescent, and the introduction of 150 c.c. at 200 pressure will not do any harm. It will not do any harm when the fallopian tubes are closed, at least in my experience I have seen no harm result in such cases.

Another thing I want to consider is the theoretical possibility of the formation of embolism. I tested this problem out by actually introducing oxygen into the vein of a dog, and found that 350 c.c. of oxygen injected into the vein did not as it were cause the dog to "turn a hair." Now, if 350 c.c. of oxygen, which is

the very maximum dose which I require for my patients, does not affect a dog by direct intravenous application, it certainly will not do any harm in the human.

I think someone asked about sterilizing the parts. The apparatus I use consists of speculum, tube, single tenaculum hook, and a cannula. These are, of course, boiled. The vagina is wiped clean of whatever mucus may be present, and the cervix touched with iodin.

Dr. L. R. Sante. The wider use of pneumoperitoneum in abdominal conditions has brought the subject from the stage of generalities to that of more special methods of examination. This you have seen to-day in the examination of the pelvic organs, by Dr. Van Zwaluwenberg, in the special examination of the spleen, and also, as mentioned by Dr Tyler, in the detection of abdominal masses. I am glad to hear, also, that Dr. Stewart spoke of the difficulty in differentiating kidney masses, and to see that he showed a case which he infers is a retroperitoneal mass.

When we first started this work about a year ago in the City Hospital in St. Louis, we were greatly handicapped to get a routine technique which would be at once rapid and sufficiently thorough to secure all of the necessary points in the examination. The number of positions in which it was necessary to place the patient was the greatest difficulty we had to overcome. We finally brought into use a type of hospital cart, balanced upon two wheels, so that mere pressure upon the cart at either end would raise or lower the head or feet. This we found most efficient.

When we first undertook this work we followed very closely the technique of the first writers upon the subject, using oxygen as an inflating medium and employing manometers to ascertain the intra-abdominal pressure. Later we used air as an injecting medium and now we use a very simple apparatus. We have dispensed with all manometers and measuring apparatus and use merely a lumbar puncture needle, connected by suitable tubing and connectors to the pump of a Potain aspirator with a Murphy drip interposed as a trap, the small vent hole of which has been plugged. The entire apparatus except the pump is sterilized. The air is not sterilized in any way. We have found that air takes considerably longer to absorb, six to seven days, than oxygen, three to four, but it surely causes less pain; and since we practice deflation on nearly all of our patients after examination, we count the use of air a distinct advantage. We have no difficulty in determining when the needle is in the abdominal cavity by simply listening with a stethoscope on the opposite side of the abdomen for the characteristic sound of the pump.

The routine procedure which we have adopted is to wheel the patient before a vertical fluoroscope while lying on his back.

The needle is inserted, and the patient inflated under the fluoroscope. When sufficient inflation is obtained, the needle is withdrawn. He is then rolled over into the lateral position and examined on each side. After this he is put in the so-called retroperitoneal position, which I will describe later, to determine if any retroperitoneal masses are present. He is then examined in both the dorsal and ventral positions on the horizontal fluoroscope.

One case, which proved to be a retroperitoneal mass, illustrated so well the position I am about to show you for the detection of these masses, that we very soon conceived the idea of using it in many other cases.

The patient presented himself with a mass in the right lower quadrant, very hard and well defined, and of questionable origin. It caused quite a controversy among the surgeons and the genito-urinary man, as a result of which we made pneumoperitoneum examination and fortunately for us, it showed the outline of the mass very clearly, and that it was in no way connected with the kidney. In an effort to determine whether the mass was retroperitoneal, we injected the ureter and kidney pelvis. We noted the smooth outline of the ureter, and then by pressure on the mass with a cone, directing the pressure upward, and inward, were able to demonstrate a kink in the ureter. This seemed to indicate that the ureter ran over the mass, and that the mass therefore was retroperitoneal. We noted, also, the carious appearance of the third and fourth lumbar vertebrae, and suspected a tuberculous abscess. He was then put in this position—chest and thighs supported by two blocks—with his abdomen hanging loosely between; exposing from side to side, we obtained a view of the retroperitoneal and prevertebral space. The mass was retroperitoneal, and proved to be a psoas abscess. You will note that the prevertebral space, which is usually clear, is encroached upon in this way. This case demonstrated so well the advantage of this position

in demonstrating retroperitoneal involvement that we began to utilize it for this purpose in other cases.

This is a diagram merely to show the arrangement of the abdominal organs in this position; the abdominal wall sagging between two blocks permits the intestines and all organs with mesenteric attachment to fall forward, showing clearly the retroperitoneal structures and clear prevertebral space. If there is a retroperitoneal mass, this mass encroaches upon this clear prevertebral space.

The first case is a mass which was not attached to the anterior abdominal wall. In this case, we rolled the patient on the side and showed that the spleen was high up under the diaphragm and entirely independent of the mass. To determine whether the mass was connected with the kidney, we injected the ureter wth thorium, and found an irregular mass in the midst of this area. The colon was injected to see if it was the origin of the mass, but it did not seem to have any connection with it. Examination in the retroperitoneal position, however, disclosed very clearly that the mass was retroperitoneal, and was closely associated with the left kidney. We have used this position successfully in determining the presence and origin of a sarcoma of the kidney; a retroperitoneal carcinoma secondary to carcinoma of the prostate, and closely associated with the kidney; a perinephritic abscess; a psoas abscess; an abscess arising in the seminal vesicle and a retroperitoneal carcinoma secondary to a carcinoma of the bladder.

I feel that with more extensive use this position will prove of great diagnostic value in determining the retroperitoneal character of masses.

Dr. Carlos Heuser, Buenos Ayres. With the dental anaesthetic apparatus of Clark, intended for oxygen gas and ether, I use a mixture in the proportion of 35% gas to 15% sulphuric ether by drops which are mixed with the gas and 55% oxygen, giving 1500 to 3000 c.c. of this mixture with my special needle. The advantages are as follows:

1. The patient can be examined standing. Deep breathing does not hurt him..
2. The mixture is absorbed rapidly.
3. The patient is not left with any pains.
4. The method can be used in the consulting room.
5. There have been observed no abnormal symptoms.
6. With the manometer attached to the instrument, it is possible to measure the quantity of gas injected, to know the pressure, and whether or not the gas mixture has penetrated into the abdominal cavity.

The needle is of platinum with a special mandrin and an escape key similar to the ordinary trocars. The purpose of the mandrin is to prevent the needle from bending when the puncture is made. The cannula with the escape key gives escape to the air after the roentgenogram has been finished. I leave the cannula in the abdomen during the making of the plates. I consider this method a great advantage and a great relief for the patient.

Dr. W. C. Alvarez. Generally we put in gas with the patient on his back. It seems to me that this gas might be trapped on one side or the other, depending on whether he rolls over to the right or to the left. Much depends, also, on whether the body is quite even on the table.

I think this type of case which Dr. Sante has just described is the type in which you must use oxygen or air or something else that will stay. It is well not to use too much; one to two litres I find is generally sufficient. Don't do this work for idle curiosity, and don't do it if there are any signs of inflammation.

Dr. A. F. Tyler. I would like to ask Dr. Alvarez if he has had any trouble in introducing carbon dioxide with the patient going into shock.

Dr. Alvarez. I have had nothing like that.[1] Most of the patients have had very little trouble. Don't let them sit up or stand up until they have had the gas in them for some time.

Dr. William H. Stewart. Dr. Rubin's work on testing the patency of the fallopian tubes by means of injecting oxygen into the uterine cavity is entirely foreign to pneumoperitoneal *x*-ray diagnosis, so much so that the speaker does not feel competent to discuss the communication although he can readily appreciate the value of such a procedure.

[1]Note: Since this meeting I have seen one case with most alarming cyanosis and stoppage of the heart, showing again that this technique should not be used thoughtlessly or needlessly.

Dr. Van Zwaluwenberg's presentation has been most enlightening, particularly so as the practical value of pneumoperitoneum in pelvic cases has long been a question in the speaker's mind. Many gynecologists will not accept the method as a routine procedure, saying that they are able, except in some very obscure cases, to make their diagnosis without pneumoperitoneum. There is every indication, however, that the method will be so simplified that it can be used in all cases where a diagnosis cannot be made by the ordinary methods.

Dr. Sante's remarks with reference to the question of gas collecting on one side of the peritoneal cavity, is debatable. Personally the speaker believes it is purely a coincidence, for unless the abdominal cavity is inflated to a considerable extent the gas is apt to collect in any one place. One of the difficulties to contend with in this work is to obtain a uniform distribution of the gas. Intestines which are distended with gas or feces will prevent this uniform distribution, and frequently form pockets in the peritoneal cavities where the inflated gas will accumulate.

Dr. Alvarez' communication is most important and great credit should be given to him for the suggestion of the use of carbon dioxide instead of oxygen. The inflation technique which we are employing at the present time is somewhat similar to that reported last year. If a complete fluoroscopic as well as roentgenological examination is required, oxygen is the gas of selection. Should the investigations be of a single organ, such as the gallbladder, carbon dioxide is used. This gas is absorbed very rapidly, usually disappearing in about half an hour. A mixture of 2 parts of carbon dioxide to 1 of oxygen is very satisfactory where the investigations will consume about an hour.

[The speaker showed lantern slides of a series of cases in which pneumoperitoneum had proved of great value in securing a diagnosis.]

THE COLLATERAL TREATMENT OF MALIGNANT PATIENTS UNDERGOING RADIOTHERAPY*

By E. H. SKINNER, M.D.

KANSAS CITY, MISSOURI

PROBLEMS are constantly arising in the management of malignant patients who are undergoing radiotherapy. The comfort of our patients and their symptomatic care is quite another thing from the actual application of radiant energy.

There are two aspects to radiotherapy and the malignant patient. The one presupposes that the application of the radiant energy is the one essential. The patient and his disease are overlooked in an ambition to secure the proper dosage and consequent shrinkage of the tumor mass.

The viewpoint that I wish to present may be summed up in the aphorism: Beyond the cancer is the cancer patient.

If we had a panacea for malignancy in radiant energy there might be some excuse for overlooking the patient and simply treating the malignancy. Unfortunately this is not so. Therefore we shall probably achieve a more reasonable success if we observe ways and means to promote the comfort and symptomatic relief of our patients. The more one is engaged in the handling of this class of patients, the more does one realize that our therapy is far from being a specific in spite of the remarkable changes that the tissues obtain from radiant energy.

The chief difficulties with our malignant cases are poor morale, deficient appetite, irradiation sickness, distressing local symptoms and the subtle changes in the blood and internal secretions. Upon the latter, much may be conjectured, little is known; but it may not be amiss to venture certain observations, relate certain animal experiments and their possible application in ra-

*Read at the Twenty-first Annual Meeting of The American Roentgen Ray Society, Minneapolis, Minn., Sept. 14–17, 1920.

diologic practice. The former group of systemic difficulties is met in almost every case of desperate malignancy. The local symptoms necessarily vary with the type of involvement.

The subject easily divides itself into the following headings:

1. The mental attitude of the patient.
2. The general state of health of the patient.
3. The dietetic care of the patient.
4. The adjuvant therapy of local and general symptoms.
5. Amelioration of symptoms by variation of dosage.

The Mental Attitude of the Patient.—Patients come to the radiologist with great hopes of relief and possible cure. Every effort should be expended to maintain this attitude even to the extremity of prevarication, because it is noticeable that the patient loses rapidly as soon as he loses hope. This hopeful attitude is an enormous factor. The physician should, however, never fool himself or the family. There should be a perfect understanding between the radiologist and some responsible member of the family.

On the other hand if the patient comes to the radiologist reluctantly and without hope it behooves one to make every effort to raise the morale of the patient by encouraging the fighting spirit and hopeful attitude. This is hardly fair in the absolutely hopeless case. The judgment and experience of the radiologist is far more important than the potency of his irradiation in this situation. Again would I invoke the words of Shakespeare:

> . . . to thine own self be true,
> And it must follow, as night the day,
> Thou canst not then be false to any man.
>
> *Hamlet,* Act I, Sc. 3.

This buoyancy of hope is a greater factor than tonics in maintaining the general condition and the appetite of the patient. The cheerful attention of the physician and those in contact with the patient and the minimizing of the symptoms to the patient are worthy ideas.

The General State of Health of the Patient.—The general state of health of the patient which necessarily includes the diet should be constantly in mind, for in our efforts to eradicate malignant tissue we may be taking advantage of the reparative powers of the patient or developing gastric symptoms which will negative our local results. Every radiologist must be cognizant of the violent gastric symptoms which are coincident with radiant therapy, especially of the abdomen. There are reliable reports of metastases supposedly caused by vigorous treatment of the apparently localized malignancy. There is ample evidence from animal experimentation that radiation has the capacity of destroying the very cell factors in the blood which are at the same time the most potent agency in the actual destruction of the malignant cell. We refer to the lymphocytes of the blood. While heavy dosage will destroy the lymphocytes, small repeated doses will stimulate their development. The thought therefore arises—is it always best to attempt to overwhelm a malignancy with deep penetrating dosage, or should an attempt be made to fortify the patient by stimulating his cellular resistance to malignancy? Furthermore, may we not be hastening or actually producing metastasis by vigorous primary radiation? The idea of immunizing the patient by gradually increasing dosage may be worth consideration.

In spite of the dissensions of opinion regarding the so-called acidity or alkalinity of cancer patients, it is our humble experience that it is more comfortable to the patient to promote the alkalinity of the excretions and at the same time quiet the gastric symptoms. The milk of magnesia is a most valuable remedy, as it tempers the stormy stomach and favors colonic regularity. The drinking of waters which carry a high soda content is more agreeable than frequent dosage with soda bicarbonate. The latter is valuable to promote a rapid alkalinity when the patient is first seen and for acute attacks of gastric discomfort, but the milk of magnesia and the waters are better for long periods of time.

The Dietetic Care of the Patient.—When one seeks the literature for information upon

the dietetics of malignancy one finds contradictory ideas. For many years the teachings of Bulkley have held us to the idea that alkalinity should be the goal. The experience of radiologists with deep irradiation sickness and the general relief of symptoms by soda bicarbonate seems to make us disciples of Bulkley. Now comes one worthy Joslin to the opposite opinion with an interesting array of argument:

"There never was in the world two opinions alike, no more than two hairs or two grains; the universal quality is diversity." *Montaigne.*

"Inconsistencies of opinion, arising from changes of circumstances are often justifiable." *Daniel Webster,* Vol. v, p. 187.

"Thus times do shift—each thing his turn does hold;
New things succeed, as former things grow old."—*Herrick.*

Experience and custom seem to demand that the general diet should tend toward alkalinity. Milk and the vegetables and cooked fruits and cereals are easily the basis of the daily dietary. Bulkley has outlined very specifically the intimate details of rotating variations in the daily meals. Torbett has furnished an alliteration that sticks: "Prunes, plums, peanuts; Canteloupe, cabbage, cranberries; these are foods which leave acid radicals in the blood." It is well to remember that spinach is richer in iron than any other vegetable and that the baked potato eaten with the skin furnishes a great deal of lime. Whole-wheat bread and popcorn are happy thoughts.

Dietetic experiments upon rat tumors, quoting Corson-White, reveal that a diet of vegetable protein, fat, and carbohydrates retard the growth of tumors, while the general condition of the animal seemed normal. On the contrary, high cholestral feedings seem to increase tumor growth. Hunt Reid finds that it may be well to consider diets that influence the ductless glands; oats and potassium iodide stimulate the thyroid, while eggs and milk inhibit the thyroid.

As an element which may be of increasing interest we would suggest blood transfusion for the patient who has a decided alteration in the blood picture due possibly to irradiation. This procedure may be considered where there is a low lymphocyte count or a pernicious anemia. In the former it would probably be wiser to withdraw a certain amount of blood and then donate a similar amount from a properly typed doner. In the latter case—pernicious anemia—a properly typed blood could be given without any withdrawal. It is probably best to hypothocate that the low lymphocyte count is due to irradiation and there is no decrease in the red blood cells, while in the pernicious anemia the condition is a sequela of the malignancy.

The Adjuvant Therapy of Local and General Symptoms.—Therapeutic suggestions may be grouped as general or local.

General measures are Blaud's pills, bitter tonics, potassium iodide, arsenic and strychnia, arsenical injections (salvarsen), protonuclein and glandular extracts. There is no reason why the patient should be denied the possible advantages of remedial measures of historical value simply because they are now undergoing a treatment by radiation and hope.

The use of arsenical injections and glandular extracts to enhance the value of radiation is worth consideration. We would also reiterate the values of the milk of magnesia and alkaline waters as general therapeutic measures in every case.

The local symptoms vary. With uterine malignancies we have the bladder and rectal symptoms (eminent radiologists to the contrary). With sigmoid and visceral malignancy there are few local symptoms. With mouth and throat cases, there are the distressing symptoms of ptyalism, pain, and ulceration and bleeding.

Brief local measures are suggested as follows:—Pelvic malignancy: Peroxide cleansing. Mild astringent tampons. Chloretone and icthyol tamponage. Acetone packing.

Dakinize with extreme care for the viable tissues for twenty-four hours at three days' interval.

Breast Malignancy: Potassium permanganate for ulcerations. Salt pork poultices. Screening with parafine mesh. Balsam peru. Peroxide cleansing. Aristol dressing.

Mouth Malignancy: Potassium iodide to promote mucous membrane activity and atropine in alcoholic to physiologic equilibrium for ptyalism. Potassium chlorate for mouth wash. Pack ulcerations with soda bicarbonate. Silver nitrate applications.

Pain: Start with aspirin. Add phenacetine. Turn to papine. Then codeine. Terminal refuge is morphine.

The cancer patient is entitled to relief from pain, as there is nothing to be gained by fighting the pain or bearing the pain. It is bad enough to endure an incurable malignancy, so why add the burden of pain and discomfort. Irradiation surely reduces and sometimes eliminates the pain and it surely affords an easy exitus for the desperate malignancies even if it does no more.

There is no doubt but that irradiation by *x*-ray and radium is the greatest boon that the malignant patient has had during all the ages, and it has surely come to stay as a possible cure in many conditions; at least a prolongation of life is assured, and always comfort to the patient when not a cure.

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-SECOND ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY
WASHINGTON, D.C., SEPTEMBER 27, 28, 29, 30, 1921
Headquarters, Meetings and Exhibits: Hotel Washington. Hotels: Hotel Washington and The New Ebbitt.

SIXTH ANNUAL MEETING THE AMERICAN RADIUM SOCIETY
BOSTON, JUNE 6 AND 7, 1921. HEADQUARTERS, HOTEL BRUNSWICK

WASHINGTON MEETING

PRELIMINARY ANNOUNCEMENTS

Plans for the program of the Annual Meeting of the Society next fall are now well under way. Dr. Réné Ledoux-Lebard will give the Caldwell Lecture on the subject of "Deep Roentgen Therapy." It is planned to give a much larger place on the program to papers than has hitherto been done. The plan is to hold the meeting for four days, giving the entire first day to papers on therapy and to have the papers on physics during the forenoon of the second day. This will enable those who are interested only in therapy to leave about the middle of the second day, while those interested only in roentgen diagnosis would not feel it necessary to attend until the beginning of the second day. Those interested in both diagnosis and therapy would probably wish to be present the entire four days.

It is believed that this plan will make the meeting of interest to a much larger number of men. It is requested that those who have papers to present at the meeting communicate with the President of the Society at as early a date as possible.

A. C. CHRISTIE.

The Twenty-second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY will be held in Washington, September 27, 28, 29 and 30, 1921. Headquarters, meetings and exhibits will be at the Hotel Washington, Pennsylvania Avenue, opposite the Treasury.

Hotel accommodations for members and guests may be arranged at the Washington Hotel and The New Ebbitt. In making reservations state that you are attending the meeting of THE AMERICAN ROENTGEN RAY SOCIETY. Mr. A. Gumpert, Manager of the New Ebbitt, has agreed to see that all those attending the Convention are taken care of. Therefore anybody not getting what he wants should communicate direct with him.

The hotel rates are as follows:

Hotel Washington, every room having private bath with shower, tub and running ice water (European plan only):

	Per day
Single rooms	$5.00 to $7.00
Double rooms (double bed)	8.00
Double rooms (twin beds)	10.00 to 12.00

The New Ebbitt (European plan only):

	Per day
Single room without bath	$2.50
Single room with bath	4.00
Double room without bath, each person	$2.50
Double room with bath, each person,	3.50

Also a number of large suites, both with and without bath, which will comfortably accommodate upwards of four persons. On

these suites they would make a rate of $3.00 per day each person, with bath, or $2.00 per day each person without bath.

For information regarding the program, those wishing to read papers or to show slides at the meeting should communicate direct with the President, Dr. A. C. Christie, 1621 Connecticut Avenue, N. W., Washington, D. C.

For information regarding commercial exhibits and other business matters connected with the meeting, address the Business Manager, Paul B. Hoeber, 67-69 East 59th Street, New York City.

It is hoped to arrange for special trains and cars from various sections. Details regarding this will be announced later.

THE CALDWELL LECTURE FOR 1921

THE AMERICAN ROENTGEN RAY SOCIETY is very fortunate in having secured Dr. Réné Ledoux-Lebard of Paris to give the Caldwell Lecture at the annual meeting this year. The distinguished standing of Dr. Ledoux-Lebard as a roentgenologist and his charming personality make it certain that the high standard already established for this lecture will be maintained.

ANNUAL MEETING WESTERN SECTION

The officers of the Western Section of THE AMERICAN ROENTGEN RAY SOCIETY are making plans for their second annual meeting. They have selected Portland, Oregon, as the place of meeting, and the time has been set for May 27th and 28th. This time will permit of a continuous trip for the western men who desire also to attend the A. M. A. meeting in Boston.

The Pacific Coast Roentgen Ray Society will meet at the same time and place, the two organizations being the guests of the Portland Roentgen Club, a very active organization of specialists.

The Secretary of the Western Section would welcome a visitor or two from the East with papers or demonstrations, and can assure them of a very enjoyable meeting. Address Dr. Warner Watkins, Box 1328, Phoenix, Arizona.

REPORT OF MIDWINTER MEETING CENTRAL SECTION

The Second Annual Midwinter Meeting of the Central Section of THE AMERICAN ROENTGEN RAY SOCIETY was held in St. Louis, at the Hotel Statler, on February 21 and 22, with about eighty-five in attendance. The program for the two days is as follows:

Monday Morning, February 21, 1921

9:30 Opening with a Business Meeting.
Appointment of Nominating Committee.
DR. J. M. MARTIN, Dallas, Tex. *X-ray Treatment of Acne Vulgaris.*
DR. D. Y. KEITH, Louisville, Ky. *Sarcoma Therapy.*
DR. CHARLES C. GRANDY, Fort Wayne, Ind. *Fracture of the Pelvis.*
DR. L. T. LEWALD, New York City. *Report of a Case of Hernia of the Diaphragm on the Right Side* (Confirmed by operation).
DR. D. C. UPSON, Battle Creek, Mich. *Situs Inversus.*
DR. H. J. ULLMANN, Chicago, Ill. *The Use of the Sphere Gap for Measuring Voltage in Roentgenotherapy.*
1:00 Lunch.
2:00 Election.
By Invitation:
DR. GEORGE DOCK, Professor Internal Medicine, Washington University Medical School. *X-Ray from the Viewpoint of an Internist.*
DR. J. M. CORK. *The X-Ray Spectrum and its Relations.*
MR. FRANK RIEBER, San Francisco, Cal. *The Importance of Accurate Standardization of Tube Potential in Therapy.*
DR. CHARLES HUGH NEILSON, Professor Internal Medicine, St. Louis Medical School. *The Internist's Viewpoint of the Roentgenologist.*

Dr. P. M. Hickey, Detroit, Mich. *Roentgen Diagnosis of the Pancreatic Cysts.*

Dr. A. W. Crane, Kalamazoo, Mich. *Reconsideration of the Barium Meal.*

Dr. E. H. Skinner, Kansas City, Mo. *Congenital Atresia of the Esophagus.*

Executive Session for the Election of Officers.

Monday Evening, February 21, 1921

7:00 Banquet.
Lantern Slide Exhibit.

Tuesday Morning, February 22, 1921

9:30 Clinical Visit to Washington University Medical School and Barnes Hospital.
Tentative program had been arranged as follows:
(a) Dr. E. L. Opie, Professor of Pathology, Washington University Medical School. *Tuberculosis* (Demonstrations of specimens, lantern slides, etc.).
(b) Dr. R. Walter Mills, Dr. Sherwood Moore. *Demonstrations in the X-Ray Department.*

12:00 Central Dry Plate Company Visit.
Buffet Luncheon (Courtesy Central Dry Plate Company).
Practical Demonstration of the Various Stages in Dry Plate Manufacture.
Visits to Local Laboratories.

The morning and afternoon sessions of the first day were occupied with reading and discussing the very interesting and scientific papers by the members and invited guests. These papers ranged in subjects over the viewpoints of the physicist, internist, diagnostician, and therapist.

Dr. Dock and Dr. Neilson, Professors of Internal Medicine in the Washington University Medical School and in the St. Louis University Medical School, respectively, brought out an important point which could be taken as a criticism in part of the roentgenologist and in part of the consultant: viz., that while there are many cases in which diagnoses can be given on one examination, there are still a large number that should have repeated examinations before the positive findings are rendered. They cited as instances, cases sent long distances because of chest findings, and major operations undertaken because of abdominal findings.

The banquet was well attended, and the pleasing music provided by the St. Louis Committee was enjoyed by all. The toastmaster, Dr. Skinner, won the hearts and applause of all when he announced that owing to the lateness of the hour and the previous entertainment, speeches would be dispensed with.

The lantern slide exhibit, following the banquet, lived up to its usual reputation, and was the most fascinating part of the meeting. Dr. R. Walter Mills presented a series of interesting stomach slides with tables showing his classification of the different types of the human form, each type having its characteristic stomach picture. Many other members exhibited a variety of slides, and much good-natured rivalry was brought out in trying to show some condition or anomaly not previously seen by one of our visitors.

The midnight sessions were held as usual in the various rooms.

On the morning of the second day the members were driven to the wonderful University Medical School and Barnes Hospital, where Dr. Opie, Professor of Pathology, lectured on tuberculosis, using lantern slides for demonstration.

A splendid buffet luncheon was served to the Society at the Central Dry Plate Company, after which the plant was inspected and the methods of plate-making were seen. It was necessary to traverse the dimly lighted parts of the factory in chain-gang fashion, as the ordinary dark-room is lighter and more easily negotiated.

A vote of thanks was given to the St. Louis Committee for their splendid arrangements and entertainment.

Dr. J. G. Van Zwaluwenberg presided.

Dr. A. F. Tyler, the Secretary, was unable to be present; Dr. William M. Doughty was appointed Temporary Secretary.

The Local Committee consisted of Dr. Edwin C. Ernst, Chairman, and Drs. E. H. Kessler, Fred B. Hall, M. B. Titterington, and L. R. Sante.

The following officers were elected for the next year:

President
Dr. William M. Doughty, Cincinnati, Ohio
First Vice-President
Dr. D. Y. Keith, Louisville, Kentucky
Second Vice-President
Dr. E. S. Blaine, Chicago, Illinois
Secretary-Treasurer
Dr. A. F. Tyler, Omaha, Nebraska

The next meeting will be held in Chicago, the date to be decided later.

ADDENDUM

Dr. Alfred S. Doyle makes the following addition to his article on page 73 of the February issue:

In the American Atlas of Stereoroentgenology, Vol. II, Dr. H. M. Imboden of New York reports a case injured in October, 1916, which was operated upon October 11th, for depressed fracture. Roentgen examination made November 8th shows an area of diminished density in the upper portion of the cranium which he believed at that time was air in the cranial cavity. On December 7th of the same year another roentgen examination was made and shows the air completely displaced by brain tissue; this patient is reported as having made a complete recovery without operation for the air.

DOSAGE MEASUREMENT

A Criticism

By J. S. SHEARER
CORNELL UNIVERSITY, ITHACA, N. Y.

Some years ago the writer of this article published a paper on the photographic effect of *x*-rays when variations of current and voltage were made and *no* filtering material except the walls of the tube and the usual paper envelopes were between the target and the sensitive emulsion. The results showed that for a *given* wave form the time required to secure identical blackening of spots on the same plate could be quite accurately computed by assuming that:

1. The time was inversely proportional to the current when voltage and distance were unchanged.

2. The time was inversely proportional to the *square* of the *effective voltage* when current and distance remained fixed.

3. The time was directly proportional to the square of the target plate distance for current and voltage unchanged.

Thus for unfiltered rays the photographic effect was indicated by the relation

$$\frac{\text{current} \times (\text{voltage})^2 \times \text{time}}{(\text{Target} - \text{plate distance})^2}$$

Also the reasonably accurate reproduction of results with different machines, as indicated by photographic action when reasonable care was taken, suggested the use of these measurements *in the place of Kienböck strips or pastilles.* This was advocated because observation of the work of many students showed there was better agreement in results than when the prevailing methods were employed. Measurements by ionization methods have indicated the above formulation to be substantially correct within the range of voltages in common use and where wave forms do not vary too much. Also, since in this same range "spark gaps" are nearly proportional to voltages, gap measurements may be substituted for voltage. The use of this method has become fairly general in this country, and we now see statements of current, gap, filter, distance and time as a rule instead of so many H or X units.

The general principles of physical measurements are sometimes rather complex and are often not well understood. This is always true when methods are developed and units adopted before facts can be fully investigated, also methods are frequently applied in ranges outside their proper limitations.

As an example, assume that we wish to use a photographic method to measure light. Let portions of a plate receive exposures for 1, 2, 3, 4, etc., units of time to radiation from a constant source. No one would question that here exposures would be in proportion to the times. If we lay off along a horizontal axis a series of equal steps as 0-1, 1-2, 2-3, etc. (Fig. 1), we may erect perpendiculars

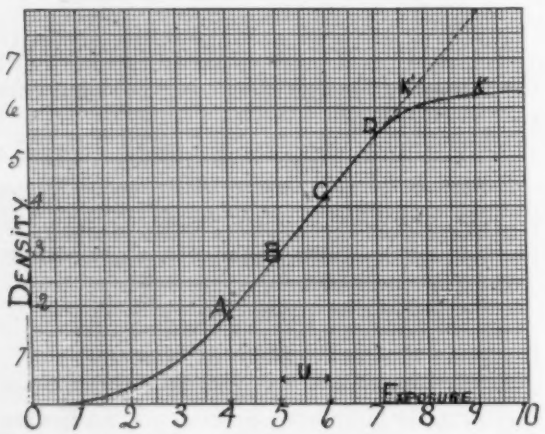

FIG. 1. VERTICAL LINES SHOW DENSITIES CORRESPONDING TO EXPOSURES SHOWN AT BASE. Thus A4 is 1.9 in length, B5 is 3 units, or 4 arbitrary exposure units gave 1.9 units of density.

at these points whose lengths correspond to the measured density of the negative where these exposures acted. Suppose one made measurements between A and D, and observed that here density increased very nearly in proportion to exposure. A unit for exposures might be chosen as U, and we say that A received 4 units, B, 5 units, C, 6 units. Any other area having a density *equal* to that at A would also be said to have received 4 radiation units. If now we attempt to use the density of the negative as a measure of exposure below A, or above D, we have trouble, since a small exposure may cause *no* measurable density. Neither can we infer from the density K what exposure the corresponding spot received. For had the relation between exposure and the density produced not changed, then this particular density would have been attained by a shorter exposure. Thus no determination of exposures below or above certain limits are possible: below there is little or no density, while above the density changes but slightly even with great increase in exposure.

The same applies to a pastille, too little exposure will not cause a perceptible color change, and after a certain yellow brown tint is reached no further change in tint is observed. Also if an exposure *exceeding* certain limits is made there is no way of determining *how much excess radiation has been received.* Pastilles were introduced when induction coils and gas tubes were in general use and there were wide differences in outfits. The fact that their maximum change in tint was so nearly attained by exposure to a quantity of radiation that could safely be delivered to the skin made them exceedingly valuable for skin therapy at that time. But in the use of fractional doses, heavy filtered doses, and when we consider the difficulties of keeping and reading pastilles we recognize the need of some other measure.

We sometimes say that one quantity "runs parallel" with another, meaning they increase or decrease together in a fixed ratio. Thus on the straight line portion of Figure 1, exposure and density "run parallel" over a considerable range, but not over all ranges. The biological action of many, perhaps of all stimuli, varies with the dose according to a law similar to that "of decreasing returns" in economics, or by an approximately logarithmic or exponential law. Thus Figure 2

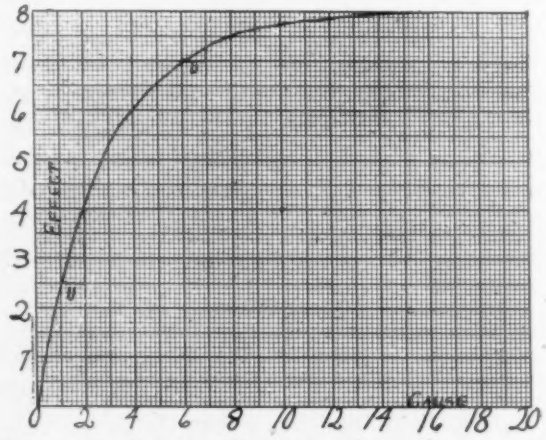

FIG. 2. A COMMON RELATION OBSERVED BETWEEN CAUSE AND EFFECT. The second unit of cause gave 1½ effect units. The 7th only .3 of a unit.

shows such a curve. To assert that each unit of the acting agent produces the same effect would be absurd, as successively applied units of causation give entirely different additions to the effect. And yet that is just what is so often done in the use of "pastilles," Kienböck's, etc., in therapy.

The therapist *need* not be concerned with such units at all. What he needs to know is *how to operate his tube to secure* the most favorable curative result with the least risk; viz., what current, voltage distance, filter, time, areas of entry, and intervals between treatments are most likely to secure a good therapeutic effect with a minimum risk of skin lesion. Also under what conditions may this dose be exceeded and by how much, when the net result may be favorable to the patient, even though temporary injury to the skin ensues.

Such a specification of dosage may seem not to involve any consideration of the laws of physics. But *this is not the case* and especially so when one considers questions of deep therapy, of filters, of proposed variations in apparatus and countless other phases of the development of therapy in which we are bound to be guided by our concepts of physics. The well established laws of radiation need no defence, neither do their careful consideration in the matters at hand require any apology.

It seems to the writer quite unfortunate at this time, when we are shortly to be able to clear up many of the disputed points in therapy, to have several articles in this and other journals giving quite erroneous interpretations of observations. The first article by Remer and Witherbee in June, 1917, questioned the voltage law as measured by pastilles. There was no reason to assume that photographic densities and color changes would run parallel to each other or either of them to skin effects over any considerable range. And no claim had been made that such was the case.

In this same article the inverse square law was questioned when filters were used. While the writer dislikes to appear controversial, references to his work have been made in several of these articles, and he has recently received letters from many sources asking if the published results are in accord with his experiments. This seems to make a public answer unavoidable, especially as the writers of some of these letters say they had unfortunate results when believing they followed Witherbee and Remer's formulation.

As in many other cases many of the *observations* of these authors are of value even though their *explanations* may be wrong, but explanations based on incorrect ideas almost invariably lead, sooner or later, to absurd or dangerous procedures. In some cases they result in the development of improper or useless appliances, in others in serious injury to patients, and they always tend to bring the work into disrepute.

When writers challenge the validity of well established physical laws they must expect a critical scrutiny of their contentions. So in the present case we may consider various statements of these authors as to their concordance and probability. In all of Witherbee and Remer's work full reliance is placed on their pastille readings or on color changes on the skin. As regards the latter one might secure a fairly pronounced erythema that would hardly be deepened in color by a considerable increase of exposure. There may also be quite a difference in biological effects at greater depths for the same apparent erythema. As regards the comparison of erythemas and coloration of the skin it would be well to remember that preconceived notions may unconsciously greatly influence readings in color matching. It is certainly questionable whether an ordinary photograph of the patient's skin is a reliable indication of the effect of radiation.

Taking now the article by these authors in the *N. Y. Medical Journal,* June 26, 1920. We may note reference to the work of 1917, where it was first asserted that the inverse square law was in error for filtered rays. All factors except distance remaining the same it is stated that at half distance one gets only twice instead of four times the dose. Or if

one gets, say, 4 units at 10 inches one would get 2 at 20 inches instead of only 1.

Such a result is contradictory to all physical experience with radiant sources as small as we have in the *x*-ray tube where the variation of distance from various points of the source to an external point is too slight to consider. The claim is also self-contradictory since any given filter absorbs a definite *fraction* of the radiation it receives quite independent of the intensity. Placed close to the source more is received and more absorbed, further away less is received and correspondingly less is absorbed, but always the same fraction of that received.

Now the authors admit the inverse square law is all right for unfiltered rays.

Suppose a filter, F, (Fig. 3), is placed at 5 inches from T and the radiation is received on an areas S just beyond F. Let F receive 8

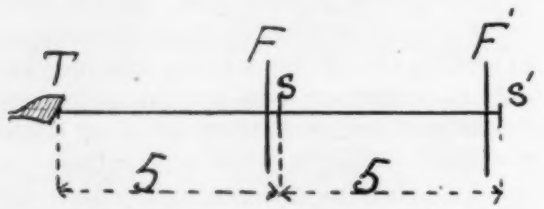

FIG. 3. F just in front of S receives 8 units of radiation, it filters out ½ or transmits 4 units. This gives only one unit on an area S′ equal to S but twice as far away. Remer and Witherbee say it gives 2 units. Transfer F to F′, they admit that if not filtered the intensity at F′ (no filter at F) would be only 2 units and it removes 50% and we get only 1 unit on S′.

arbitrary units of radiation per sq. cm. and be of such a thickness as to absorb 50 per cent of this amount, then a sq. cm. perpendicular to the rays just beyond F would receive 4 units. According to Witherbee and Remer a sq. cm. of surface S, at 10 inches would receive two units instead of only one as predicted by the inverse square law. Now move the filter twice as far away to F; at 10 inches it is admitted that the filter would *receive* only one fourth of what it did at 5 inches, or only 2 units.

Receiving only 2 units and absorbing 50 per cent of what it received, it would transmit only *one unit*. So it would follow if the physical law is not obeyed it would make a great difference where we placed the filter, while in fact it makes no difference.

It is interesting to observe that their claim as to the effect of distance is exactly comparable to their observation on change of voltage, i.e., if the V^2 law is true we would have four times as much rediation for a doubled voltage. They say only twice as much. Halving the distance gives four times as much radiation on the same area, but these authors say they read only twice as much. Does it not seem strange they should get this *exact* discrepancy in two different cases and, granting as good readings as possible, would not one be justified in doubting the method?

Next in this article we read that dosage is not in proportion to time. Using 3 mm. of al. and all remaining conditions the same:

2 min. gives 1 H
2 × 2 min. gives 1½ H
3 × 2 min. gives 2 H

Summarizing, if at a voltage V, distance D, and time T, we get a dose H:

		Physical laws predict:	Witherbee & Remer assert:
At	½D	4H	2H
At	2V	4H	2H
At	3T	3H	2H

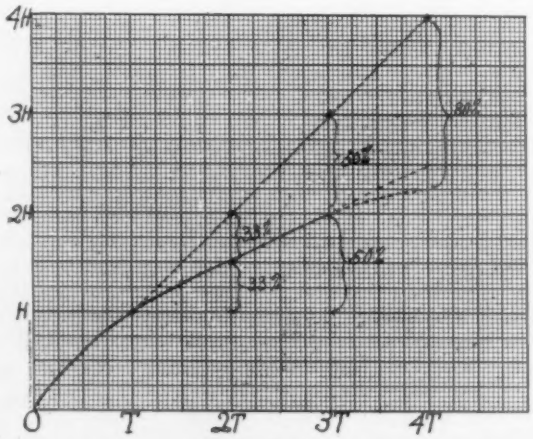

FIG. 4. INCREASE IN DOSE INDICATION WITH EQUAL INCREMENTS OF TIME. Dotted straight line shows how an indicator ought to behave. Full line shows Remer and Witherbee readings. Exterpolated beyond by dotted lines. Uncertain just how it would read at 4T.

This failure of the pastilles to read in proportion to *time* according to the observations reported is significant. In Figure 4 the straight line shows the increase of dose with increase of time, all other factors unchanged.

T = time for 1 skin unit. But their reading at 2T must be increased by one third of itself to come to 2H, the reading at 3T must be increased by 50 per cent of itself to give 3H, and extending the curve, in the absence of readings, to 4T, indicates that the *reading* at 4T would have to be increased about 80 per cent to satisfy the law of constant increase with time. Hence if under one set of circumstances the pastille is so much too low that one must add 80 per cent to 2H to get a rational measure, just why not add, say, 100 per cent to the 2H reading in the voltage and in the distance experiments?

The law of *uniform increase of dose with time* for all other conditions constant has always been used to determine the fractional scales for both the Kienböck and pastille methods. After a reading of 2H was attained we were told to *double* the *time* for 4H. Thus the scales used by these authors were fixed by using the laws whose validity they deny.

There should be a careful distinction between applied dose and the effect produced by the application. Thus if 5H is the *dose* received by a pastille it shows a marked change in color, if an additionad *dose* of 5H is then applied but little further color change is shown. The dose is a physical entity, its effect is dependent on the variable state of the receiving substance. Also if a tendency to recover is present we have another factor involved. Thus with very weak radiation in moist air and diffuse light one may have the rate of recovery of a pastille just balance the action of the radiation, yet one would hardly claim no dose.

In this same article we read as follows:

"Recently the pastille readings were taken using ¼, ½, 1, 2, 3, 4, 5, 6, and 7 mm. of aluminum, respectively. Throughout these experiments, instead of the half distance pastille registering *twice* the amount of that at full distance we find that when the half distance pastille reaches *one* and *a half* skin units the full distance pastille reads *one skin* unit and when the half distance pastille reaches two skin units the full distance reads one and a quarter. The only exception to this is when 5, 6 and 7 mm. of aluminum are used. These register half the dose of full distance and formula. This agrees with the biological results."

It is rather strange that *only after 5 mm. are used do we get agreement with biological results.*

In their previous work they declared a ratio of 1 to 2 for 3 mm. of aluminum at full and half distance. The physical law asserts the ratio is always 1 to 4.

Remer and Witherbee read 1 to 1.5 at first, then 1¼ to 2, or 1 to 1.6 up to 4 mm. of aluminum, then at once 1 to 2. So we see that the pastilles are not consistent with themselves as the *ratio* of readings is variable when two are treated alike for comparison.

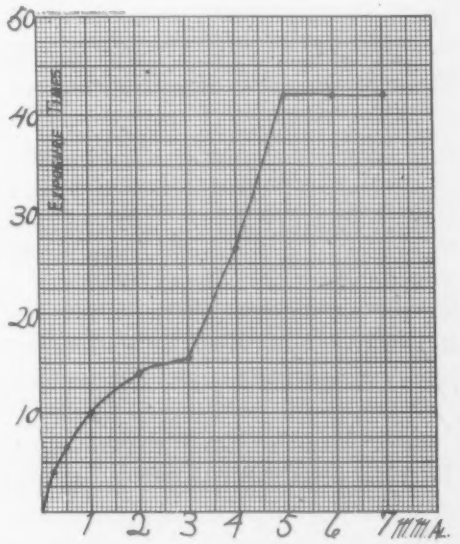

FIG. 5. EXPOSURE TIMES FOR 1H, CURRENT, DISTANCE AND GAP CONSTANT BUT USING DIFFERENT THICKNESSES OF ALUMINUM. Such an irregular line is *highly* improbable.

One way in which we may see whether results are fairly reasonable or not is to plot curves between two related quantities. Plotting from the data given, time for one skin

unit at constant gap, current and distance against thickness of aluminum used as a filter we have Figure 5. Such results are quite impossible unless *all* experiments done heretofore are wrong. Why such a break at 3 mm. and such a jump between 4 and 5? And surely no one knowing anything of the effect of thickness can believe that 7 mm. and upwards would transmit the same amount of radiation as 5 mm.

Again we read:

"The principle involved in this experiment apparently changes the classical law of light, namely, the amount of light varies from the source according to the inverse square of the distance. Filtered *x*-ray produces double the amount of half distance instead of four times.

"We understand that these results in no way conform to any existing law of physics. We have been unable thus far to explain the cause of the above phenomena and simply wish to report our findings."

The authors further remark: "We do not see the necessity of using more than five mm. of aluminum as a maximum without the addition of a piece of glass, leather, or wool." Why add glass, leather or wool? Because of some property not recognizable by physical experiment? Or because some have used these as filters? At the end of the reprint we are told their "results explain the practicability of filtered ray for producing the maximum effect on the parts beneath the skin when compared with unfiltered dosage." A fact fully explained without any need of the denial of the laws of radiation. The whole result of these arguments is, if anything, to discredit entirely such methods of measurement.

In the *Medical Record*, July 31, 1920, we have another article entitled "The Cause of *X*-Ray Burns."

There appears in this article so much that is fallacious that it constitutes a serious menace to rational therapy. Omitting the figures that purport to show equality of dosage by ordinary photography of the skin the main portions of the article may be quoted. The paragraphs are numbered solely for easy reference.

1. "During the early days of roentgenology, when the gas *x*-ray tube was all there was, we were especially warned against the use of any factors with very low voltages, for the reason that low voltages produce an immense number of rays of low penetration which are absorbed by the skin and hence more liable to cause an *x*-ray burn than the high voltages whose rays are of high penetration and not absorbed by the skin.

2. "The above theory has been handed down from year to year and it is only within the last few years that the fallacy of it has been realized.

3. "Soon after the announcement of Saboraud and Noire method of treatment of ringworm of the scalp, many attempted to carry out the procedure with an *x*-ray coil instead of a static machine as used by the originators. This resulted in overdosage and permanent baldness in many of the cases. The reason for this was the failure of the operator of the coil to maintain a constant high voltage for any length of time as compared with the tube maintained by the static machine.

4. "This drop in voltage in the gas tube no doubt increases the number of low penetrating rays, and it was naturally concluded from the theory of absorption that they were the cause of permanent alopecia or *x*-ray burn. In order to test out this theory, the following experiment was made with a Coolidge Tube and reported in the June issue of 1917 of the *American Journal of Roentgenology*.

5. "Four areas of a patient's back were treated with the following factors for each area:

MA Sp. G. T

No. 1. $\frac{3\times3\times5}{8D\times8D}$ = 1¼ skin units = 5H;

No. 2. $\frac{3\times6\times2\frac{1}{2}}{8\times8}$ = 1¼ skin units = 5H;

No. 3. $\frac{3\times4\frac{1}{2}\times3\frac{1}{3}}{8\times8}$ = 1¼ skin units = 5H;

No. 4. $\frac{3\times9\times1\frac{2}{3}}{8\times8}$ = 1¼ skin units = 5H.

6. "The photograph of the patient taken

ten days after treatment demonstrates that all areas coincide, yet in two of them, namely No. 2 and No. 4, the spark gap was doubled and one-half the time taken for exposure that was given in No. 1 and No. 3, respectively. It therefore follows that if the spark gap is doubled and the time reduced one-half, the same degree of erythema will be produced, other factors remaining constant.

7. "From the standpoint of quality of *x*-ray in the above experiment, the formula with 6-in. and 9-in. spark gaps (No. 2 and No. 4) should give a very large percentage of penetrating rays as compared with the 3-in. and 4½-in. (No. 1 and No. 3), and hence one would expect that these penetrating rays derived from the higher spark gaps, 6 and 9 (No. 2 and 4) would pass through the skin and take much longer to produce the same degree of erythema as that followed by the use of 3 and 4½-in. formulae (No. 1 and No. 3). Exactly the reverse proves true. For it took just one-half the time for the same biological effect in the doubled spark gaps (No. 2 and No. 4) as it did in the 3 and 4½-in. (No. 1 and No. 3) formulae.

8. "It is, therefore, apparent that the quality of the ray and the absorption of those of long wave length have little to do with the biological effects in the skin. On the other hand, it seems that the factor which determines this effect is solely the quantity of *x*-ray reaching the skin, for it is obvious that a high spark gap produces more rays that reach the skin than the same dose with a low spark gap.

9. "Recently we have tried out the following factors on the skin of a patient's back:

$$\frac{\text{MA Sp. G. T}}{5\times 9\times 9/1.6 \text{ min.}} = \frac{}{6\times 6\text{ D}}$$

33¾ sec. = 1¼ skin unit = 5H.

10. "This is an erythema dose without a filter. The filtered erythema dose using 3 mm. of aluminum is as follows:

$$\frac{\text{MA Sp. G. T}}{5\times 9\times 7.7 \text{ min.}} = \frac{}{6\text{ D}}$$

2½ skin units = 10H.

11. In the photograph both areas of erythema are identical. No. 1 was produced by the unfiltered erythema dose; No. 2 by the filtered erythema dose. Biologically, to all appearances, the erythema produced in 33¾ seconds by the unfiltered ray is the same as that produced in 7 minutes and 42 seconds by the filtered.

12. "If the voltage determines the quality of the ray, then in this experiment the voltage is the same in both instances; the only difference is the interposition of 3 mm. of aluminum and about ten times longer exposure for the filtered dose as the unfiltered. Here again the quantity of *x*-ray reaching the skin is materially lessened by the aluminum, thus making the enormous difference in the time of exposure.

13. "This dose with 3 mm. of aluminum takes a little over ten times as long to produce an erythema as it does without aluminum. In speaking of this dose some writers would say that they gave ten erythema doses. This statement without qualification is misleading. In reality the effects, so far as the skin reaction is concerned, are identical. If then the filtered and unfiltered erythemas are the same, the only difference being in the number of rays reaching the skin, thus increasing the time, why is it that a filtered dose is five or ten or any other number of erythema doses? The fact remains that *biologically filtered and unfiltered erythemas* are *identical,* as exemplified in Experiment No. 2, illustrated in Fig. 2; that 1¼ skin units unfiltered = 5 H or one erythema dose, also that 2½ skin units filtered or one filtered erythema dose.

14. "By increasing the thickness of the filter and decreasing the spark gap the time necessary for a filtered erythema dose, namely 2½ skin units can be progressively increased. *Although decreasing the spark gap in unfiltered dosage lengthens the time of exposure for an erythema dose,* the time ratio between the lower voltages and the thickness of the filter is many times greater than those of the higher voltages. Therefore, one might select a formula with a very low voltage and be able to say that one gave forty or fifty erythema doses.

15. "If then, in describing the *technique of filtered dosage* we adopt 2½ skin units as the standard for an erythema dose, we can use it with the same degree of accuracy as we have the erythema dose of unfiltered dosage."

Among the lessons learned by the early

roentgenologists at the price of bitter experience the one that stands without modification to-day is stated in paragraph 1. The "fallacy" is solely in the proposed explanation by these authors.

When the voltage at which a tube is operated is *reduced, rays of all kinds* (i.e., of all wave lengths) *emitted by the tube are decreased* in intensity, none whatever are increased, many are reduced to nothing. The static machine gives a larger percentage of *short* wave lengths than a coil operated at the *same spark gap*. It may also be remarked that if one operates a coil with inverse through the tube the milliampere reading will be the difference between direct and inverse so that one might even have the meter read zero and yet operate the tube. In such a case we surely would have excess dosage. But now the authors introduce experiment and then interpretation as in paragraph 7. There is here exhibited a common confusion of mind in the use of the term *quality of x-ray*. If a tube operated at a 4½ in. gap, emitted only one (ray?) i. e., one wave length, l_1, and at a 9 in. gap it ceased the emission of l_1, and substituted a new, more penetrating ray of wave length l_2, and if these carried the same energy the "much longer" contention claimed as a prediction from the theory would be well founded. But the facts are entirely otherwise, and the so-called "reverse" only shows a misconception of well founded laws. There are rays at a 9 in. gap more penetrating than *any* at a 4½ inch, also *all those present at a 4½ inch gap are present in increased intensity at a 9 inch gap.*

On account of the smaller percentage absorption of the rays of higher penetration that are *added* when the operating voltage is raised one should not expect that the time for erythema would be reduced to one-fourth by doubling the gap but the writer believes that it is reduced much more than stated in the article quoted.

Paragraph 8 is the most dangerous misstatement relating to *x*-ray therapy that the writer has read in a long time. To say that the absorption of waves of long length has *little* to do with biological effects is to contradict all experience. Again experiment and explanation. Two doses, equal according to the belief of the authors were given to a back and a photograph taken. Suppose they had given 8 min. or 9 min. with filter and 25 sec. or 40 sec. instead of 33¾ without filter, would the photographs have been different? In other words how accurately does equality of negative density or even the unaided eye as a measure of erythema indicate dosage? And if accurate enough for skin therapy are they good guides for deep therapy? Also the writer sincerely hopes no one will use a *9 in.* gap and a *6 in.* target skin distance.

In 12 we again see lack of perception of the real facts. It is true that the quality of the beam *before* filtration was the same in the two cases, also the filter did reduce the quantity of all wave lengths reaching the skin, but the reduction is enormously greater in the long wave lengths so the quality of the radiation *reaching the skin in the two cases was very different.* The only remark which we might agree with is the objection to describing dose by the number of X or H units or multiples of erythema doses.

Now it is true that the same skin effect may result from the absorbtion of equal quantities of radiation irrespective of the actual wave lengths, but the effect is never confined to the skin alone. Thus, glands are often affected to a greater extent than is indicated by the skin reaction. The patient, not simply the patient's skin, is treated.

The article in this JOURNAL (October, 1920, pp. 485-492) contains the same errors as those already cited, in fact in the main it is a rearranged reprint of the others; note the second column of page 488 and the difficult expression as to gaps on page 489.

Whether or not doses of filtered radiation such as described by these authors are both useful and safe must be left to the experience of those who use them. But to base dosage on a method that is so much at variance with well established physical laws, and giving readings inconsistent among themselves, re-

quiring such a vast amount of useless arithmetic can only lead to confusion.

Why cumber our literature with all sorts of units such as H, skin units, ½ H, Hampson units, X units, etc. No one conversant with any of these units can fail to realize the difficulties in their use. While transformers and high tension rectifiers are not perfectly comparable one with another, yet if the rectifier is properly set and the milliammeter is reasonably correct, dosage can be quite accurately reproduced.

If experience shows that a patient having a given disease is most benefited on the average by using a certain current, sp. gap, distance, exposed area, filter and time, that *specifies how to attain* the desirable dose. If the first four are constant the gap being selected properly and reasonable current and distance used, let us assume that half this dose is given when the time is halved. Then when quarter or other fractional doses are prescribed there is only one factor to divide and we have no cumbersome formulae giving a fictitious appearance of accuracy.

Finally it will probably be found that discrepancies between physical laws and amounts and quality of radiation as estimated by color changes, etc., are due either to incorrect exposition or understanding of physics or to defects or limitations in the methods of measurement. In fact the writer ventures to predict that rational radiation therapy will finally be based on the physical laws of radiation. The application of such radiation will ultimately be perfected by reference to the cumulative experience of those who apply these laws properly.

Only when dosage measurements are expressed in a common language, using terms capable of exact meaning can we hope to have the present chaotic condition clarified so as to realize at once the ultimate value and the equally important limitations of this therapeutic agent.

Again I wish to call attention to the reason for this criticism. I am questioning neither the therapy nor the care or skill in reading pastilles of the authors. Whether one should use filtered or unfiltered radiation, 6 or 12 inch spark gap, one minute or one hour, is not for me to say and I surely would not discuss such matters in print. But what therapists will do with radiation depends very much on their conception of the physical side. The extension to higher or lower voltages and choice of filters ought to be based on correct use of the physics involved, to the end that therapists may secure reproduction of results, or, failing that, may be sure that the differences are due to the patient and not to the radiation utilized.

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TRANSLATIONS & ABSTRACTS

KINGERY, LYLE B., Ann Arbor, Mich. Saturation in Roentgen Therapy—Its Estimation and Maintenance. (*Archives of Dermatology and Syhilology,* April, 1920.)

Two widely separated methods of administrating radiation with *x*-rays have been in use since the discovery of roentgen rays; the older method by which the maximum effects are gradually obtained by the administration of small doses, repeated at short intervals, and continued over a long period of time ("fractional dosage"), and differing radically, the more recent method of "massive dosage," by which the maximum effect is obtained at once. It is to be seen, as the writer points out, that in each method the maximum effect is either preceded or followed by a stage during which the tissue effects are not definitely shown. In the older method this occurs during the period before cumulative effects result in erythema. In the method of massive doses, a period of indefinite influence follows the original maximum effect.

Each cell which has absorbed roentgen rays undergoes a biochemical change, which may produce on appreciable effect, or may result in stimulation, inhibition or erythema, according to the quantity of radiation absorbed. Presumably this sequence of stimulation, inhibition and destruction always occurs; it may precede the erythema resulting from repeated small exposures, or it may follow in the reverse order, the erythema consequent to a single large exposure. In other words, the effect produced will vary according to the amount of rays absorbed by the cell, and one aspect of our problem becomes the maintenance of the optimum quantity in the cell.

This depends upon the rate at which the effects of the rays are lost. Depending on this rate is the frequency with which exposures may be repeated, and the quantity that may be administered at each exposure. The author assumes that tissues exposed to *x*-rays lose that effect in a constant manner. The greater the concentration of the biochemical products of irradiation, the higher the velocity of loss is borne out by certain observations. If this be true, and if we may assume that the rate of loss varies directly as the concentration of some hypothetical decomposition product, then as this concentration decreases, the velocity of loss will become less in the same ratio. Thus, at such time as this concentration has decreased by one half, the corresponding time rate of loss shall have become less by a corresponding amount, and so on, until the residual effect has become negligible. This rate of loss, theoretically, would represent a logarithmic curve and may be so calculated. Such a curve has been established for many chemical and biologic reactions, which we know as "mass reactions," and if we may be permitted to draw an analogy, the biochemical change resulting from the absorption of roentgen rays by tissue elements may follow a similar law.

Proceeding upon the basis of the above hypothesis, that the decreasing residual effects of roentgen rays follow a logarithmic curve, a series of experiments were undertaken by Kingery. He found that a full dose could be repeated after an interval of fourteen days without producing unfavorable complications. Trying, then, the interval at which 75 per cent and 50 per cent could be given, he found it to be seven and three and a half days respectively, that is, at the end of seven days, 75 per cent of the original dose could be given without unfavorable reaction, and at the end of three and a half days, 50 per cent of the original dose could be given. From these intervals, a curve was constructed showing the intervals at which a condition of "saturation" diminished until there is little effect remaining in the tissues. By consulting this chart or curve, it is possible at the end of four, five, six days, or at the end of any interval less than two weeks, to determine the percentage of the original dose given to bring the tissues irradiated back to the same point of saturation previously administered.

In conclusion Kingery enumerates the advantages of this method:

1. Accuracy with which desired irradiation effects may be obtained and continued.
2. Avoidance of stages of incomplete saturation, perhaps of questionable influence, by properly measured doses at proper intervals.
3. Ability to duplicate accurately effects after various time intervals, even by different operators.
4. Constant protection of patients from the results of improper time and dose relations.

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